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National Simulation Capability (NSC) Reduced Vertical Separation Minima (RVSM) Phase III Result Report

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16. Abstract

The Reduced Vertical Separation Minima (RVSM) experiment resulted from the North Atlantic Systems Planning Group (NATSPG) conclusion to carry out studies aimed at achieving early implementation of RVSM in the North Atlantic Region. RVSM is an approved International Civil Aviation Organization (ICAO) concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima (CVSM) of 2000 ft to 1000 ft, between flight level (FL) 290 and FL 410, within a designated portion of the North Atlantic Region.

RVSM Phase III simulation studies were conducted in October 1995 at the Miami Air Route Traffic Control Center Dynamic Simulation Laboratory. The study investigated workload effects and the feasibility of transitioning aircraft to and from CVSM and from and to RVSM within radar sectors R1, R60, R62, and R63 under various traffic conditions. Generally, RVSM conditions proved to be more workload intensive than CVSM conditions. However, even though workload was increased, there was no corresponding increase in operational errors or deviations with RVSM when compared to CVSM. Both controller and Technical Observer ratings revealed that interval and post-run workload ratings were either equal or higher for RVSM under contingency/emergency (RVSM-E) conditions when compared to normal RVSM conditions. Analysis of operational errors revealed the same trend; more errors were reported during RVSM-E. Therefore, guidelines to handle potential complications such as radar outages and bad weather need to be developed before RVSM can be safely implemented.

The results of the simulation generally indicate that RVSM implementation is feasible in the Western Atlantic Track Route System region. Although controllers expressed concerns about safety in maintaining separation and transitioning aircraft to and from RVSM altitudes, most indicated their comfort level would increase with increased exposure to RVSM.

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Executive Summary

The Reduced Vertical Separation Minima (RVSM) simulation resulted from the North Atlantic Systems Planning Group (NATSPG) conclusion to carry out studies aimed at achieving early implementation of RVSM in the North Atlantic (NAT) Region. RVSM is an approved International Civil Aviation Organization (ICAO) concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima (CVSM) of 2000 ft to 1000 ft, between flight levels (FLs) 290-410, within a designated portion of the NAT Region. In the United States, RVSM studies are being conducted by the Federal Aviation Administration William J. Hughes Technical Center National Simulation Capability RVSM Experimentation Working Group.

RVSM Phase III simulation studies were conducted in October 1995 at the Miami Air Route Traffic Control Center (ZMA) Dynamic Simulation (DYSIM) Laboratory. The study investigated workload effects and the feasibility of transitioning aircraft to and from CVSM and from and to RVSM altitudes within radar sectors R1, R60, R62, and R63 under various traffic conditions. Experimental findings and conclusions from the simulations were provided to Air Traffic organizations to assist in defining geographical areas and procedures for RVSM transitioning, thereby enhancing the flexibility and efficiency of the National Airspace System.

Phase III simulations investigated 11 different traffic scenarios. Scenarios varied by sector configuration and separation minima. Air Traffic Control specialists and DYSIM training specialists developed traffic scenarios based on actual recorded traffic flows. Currently certified and active ZMA controllers staffed the radar, the non-radar, and the assistant control positions. DYSIM training specialists staffed pseudo-pilot and remote controller positions.

To collect objective data for all simulation runs, each run was extensively audio and video recorded. Guided post-simulation discussions and questionnaires were used to obtain subjective data. Dynamic workload probes were recorded at 15-minute intervals to assess the level of workload throughout a run.

Generally, RVSM conditions proved to be more workload intensive than CVSM conditions. Although workload increased, there was no systematic increase in operational errors or deviations with RVSM when compared to CVSM. Both controller and Technical Observer ratings revealed that interval and post-run workload ratings were either equal or higher for RVSM under contingency/emergency (RVSM-E) conditions when compared to normal RVSM conditions. The operational errors analysis revealed the same trend; more errors were reported under RVSM-E conditions. Therefore, guidelines to handle potential complications, such as radar outages and bad weather, need to be developed before RVSM can be safely implemented.

The results of the simulation generally indicate that RVSM implementation is feasible in the Western Atlantic Track Route System region. However, controllers expressed concerns about safety with maintaining separation and transitioning aircraft to and from RVSM altitudes. Controllers also pointed out that non-RVSM participating aircraft may present a problem at crossing fixes because they will have to enforce the 2000-ft separation minima. Controllers made the following suggestions to enable RVSM to be implemented more efficiently: (a) all aircraft operating in a particular airspace should be RVSM equipped, (b) the transition airspace

should be increased, and (c) controllers should have access to more reliable radar. However, most controllers indicated their comfort level would increase with increased exposure to RVSM and, therefore, additional procedures and equipment may not be necessary.

1. Introduction

Reduced Vertical Separation Minima (RVSM) is an approved International Civil Aviation Organization (ICAO) concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima (CVSM) [1] of 2000 feet to 1000 feet, between flight levels (FLs) 290 and 410, within a designated portion of the North Atlantic (NAT) Region. An RVSM-approved aircraft must have at least two independent altitude measurement systems, one secondary surveillance radar altitude reporting transponder, one altitude alert system, and an automatic altitude control system.[2]

The technical feasibility and cost benefits of establishing RVSM in the NAT Region have been the subject of many studies conducted by affected ICAO member states. As a result of these studies, ICAO is planning for the implementation of reduced minimums in the Minimum Navigation Performance Specification (MNPS) portion of the NAT Region in January 1998. The verification trials were originally scheduled to begin in January 1997; however, the trials began in March 1997 with a limited FL range of 330 to 370.

With the support of the International Air Transport Association (IATA), RVSM studies were continued to include the portion of the Western Atlantic Track Route System (WATRS)[3] area under U.S. control. Originally, it was requested that the WATRS implementation be congruent with RVSM implementation in the MNPS airspace. However, WATRS implementation is not scheduled until at least 1998 in the U.S. portion of the airspace and as late as 1999 or 2000 in the Caribbean and South American regions.

In the United States, the Federal Aviation Administration (FAA) conducted a series of Air Traffic Control (ATC) simulations to assist Air Traffic organizations in identifying and defining the requirements for implementing RVSM in both the MNPS and WATRS airspace.

The RVSM simulation described in this plan was conducted under the auspices of the FAA National Simulation Capability (NSC) Program. NSC relied heavily on the expertise of controllers and staff from the Miami Air Route Traffic Control Center [ARTCC] (ZMA). NSC also relied on the expertise of the following organizations: Air Traffic Rules and Procedures Service (ATP-100), Air Traffic System Management (ATM-100), Air Traffic Plans and Requirements Service (ATR-300), Flight Standards (AFS-400), Program Analysis and Operations Research (ASD-400), Integrated Product Team for Oceanic (AUA-600), the Human Factors Branch (ACT-530), the Simulation and Systems Integration Branch (ACT-540),[4] the Aviation System Analysis and Modeling Branch (ACT-520), and the Washington Consultant Group (WCG).

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[1] CVSM - 2,000 ft vertical separation minimum (VSM) above FL 290 up to FL 600, inclusive.

[2] Refer to the *Interim Guidance Material on the Approval of Operations/Aircraft for RVSM Operations*.

[3] WATRS is NE of 27 33N 77 00W - 27 00N 77 00W - 20 23N 60 27W.

[4] Formally ACD-350, Simulation and Human Factors Branch.

RVSM Phase III simulations were designed to measure the effects of changes in standard operating procedures on controller workload in ZMA radar sectors R60, R62, R63, and R1. Phase III investigated

a. changes in controller workload levels as impacted by RVSM operations;

b. operational issues associated with RVSM operations in R60, R62, R63, and R1;

c. operational difficulties associated with controllers' ability to transition aircraft from and to RVSM and to and from CVSM within radar coverage; and

d. other issues related to reverting to and from RVSM and from and to CVSM.

1.1 Background

In the late 1950s, a need was identified to increase the prescribed VSM from 300 m (1,000 ft) due to the inaccuracy of pressure-sensing barometric altimeters as altitudes increased. In 1960, FL 290 was selected as the vertical limit for the 300 m VSM, and a 600 m (2,000 ft) VSM was established for aircraft operating above FL 290. This vertical limit was chosen based on the operational ceiling of aircraft at that time. In 1966, although FL 290 was already established as the vertical changeover level on a global basis, consideration was already being given to the application of RVSM above FL 290 on a regional basis. Consequently, ICAO provisions stated that RVSM could be applied under specific conditions and within designated portions of airspace. To support this provision, ICAO recognized that a thorough assessment of the risk associated with reducing the VSM would be required.

In 1980, the ICAO Review of the General Concept of Separation Panel (RGCSP) concluded that the potential benefits of reducing vertical separation above FL 290 to FL 410 outweighed the cost and time involved. Member states were encouraged to conduct the necessary evaluations. In 1982, the RGCSP coordinated studies to evaluate reducing the VSM above FL 290. In December 1988, the RGCSP reviewed the results of studies carried out by Canada, Japan, the member states of EUROCONTROL (France, the Federal Republic of Germany, the Netherlands, the United Kingdom), the Union of Soviet Socialist Republics, and the United States.

Using a Target Level of Safety (TLS) of 2.5×10^{-9} fatal accidents per aircraft flight hour, the RGCSP concluded that a 300-m VSM above FL 290 was technically feasible. Contemporary height-sensing systems can be built, maintained, and operated so that the expected performance is consistent with the safe implementation and use of a 300-m VSM above FL 290. In reaching this conclusion, the panel also found that it would be necessary to establish

a. air-worthiness performance requirements embodied in a comprehensive Minimum Aircraft System Performance Specification (MASPS) for all aircraft utilizing the reduced separation,

b. new RVSM operational procedures, and

c. a comprehensive means of monitoring the safe operation of the system.

The RGCSP identified the NAT Region as an area where early implementation of RVSM was possible because of its traffic patterns and aircraft equipment requirements. On this basis, and in view of the substantial benefits, the NATSPG, at its 26th meeting, agreed to carry out studies aimed at achieving early implementation of RVSM in the NAT Region. Worldwide and regional provisions concerning the implementation of RVSM were finalized for application in November 1992.[5]

Initially, RVSM implementation was to be within the MNPS airspace (refer to Figure 1) of the ICAO NAT Region; thus RVSM-related research focused only on that airspace. A two-phased simulation was designed to investigate and measure the effects of RVSM implementation and the associated transitions in the MNPS airspace and in the radar airspace adjacent to the MNPS airspace. Both areas are under the control of the New York ARTCC (ZNY). With the support of the IATA, it was requested that RVSM studies be continued to include the portion of the WATRS area under U.S. control. IATA felt that users would further benefit from RVSM implementation in that area. Therefore, a third phase of the simulation was added to analyze the effects of transitioning RVSM-approved aircraft in the airspace that is adjacent to and south of the MNPS airspace (i.e., the WATRS portion of the NAT Region under ZMA control).

RVSM Phase I simulation was completed in January 1994. It was a study of the transition of westbound RVSM-approved aircraft from RVSM to CVSM before leaving RVSM/MNPS airspace (refer to Figure 1). There was an exception for aircraft that entered radar coverage adjacent to RVSM/MNPS airspace or Canadian airspace (this was either MNPS or radar coverage). RVSM increased the amount of available altitudes thus providing the controller with greater flexibility for managing traffic. However, simulation results indicated that controllers operating under RVSM experienced additional coordination with adjacent sectors and facilities, increased traffic scanning times, and an increased need for information regarding when an aircraft could climb. As a result, interval increases in controller workload occurred under RVSM traffic conditions when compared to CVSM conditions. However, the overall controller workload did not increase. Results indicated that transition in non-radar sectors D71 and D72 was feasible, although controllers recommended that transitions take place in radar-controlled airspace (Seeger, 1995).

RVSM Phase II simulation was completed in September 1994. It was a study of RVSM transitions in domestic oceanic airspace (refer to Figure 2). RVSM-approved aircraft were permitted to exit or enter the MNPS airspace from the west using RVSM rules. The associated transitions would occur within the adjacent radar-controlled sectors R65 and R86 under New York ARTCC control. Results indicated that RVSM was instrumental in reducing controller workload when a majority of the traffic traveled eastbound. However, controllers reported some concerns including: separating RVSM-equipped and non-RVSM-equipped aircraft, difficulty maintaining data block separation during RVSM, and the possibility of aircraft flying into CVSM airspace at an RVSM altitude due to a temporary lack of communication (Seeger & Kopardekar, 1996).

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[5] Manual on implementation of a 300 m (1000 ft.) VSM between FL 290 and FL 410 inclusive is ICAO Doc. No. 9574-AN/934, dated 1992.

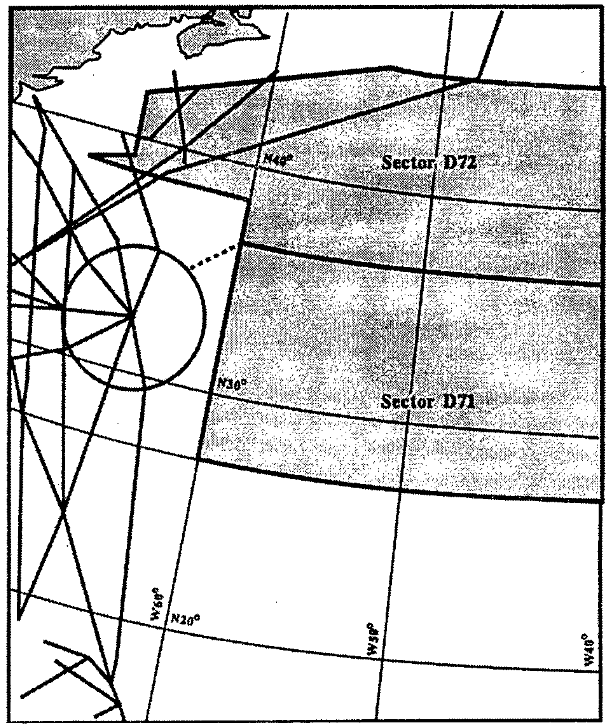

Figure 1. RVSM/MNPS airspace used for Phase I simulations.

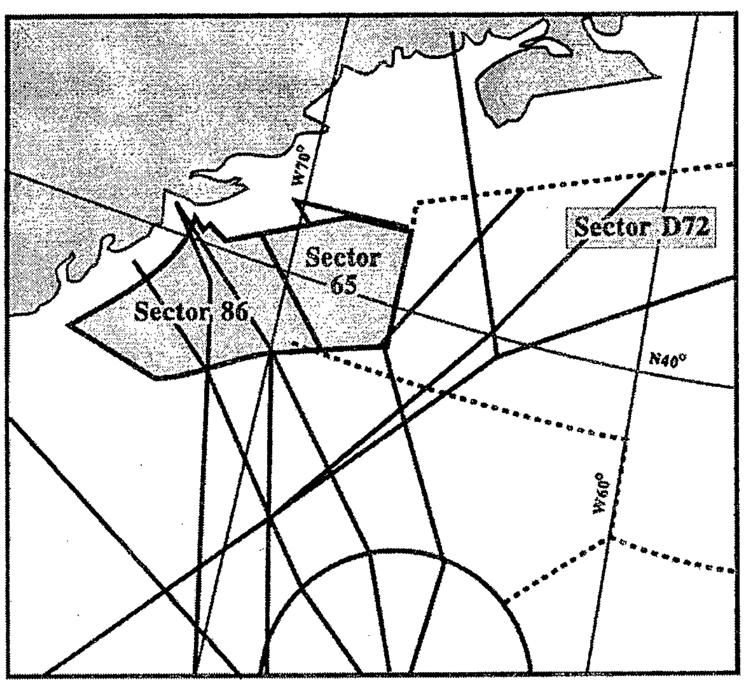

Figure 2. RVSM transition airspace used for Phase II simulations.

RVSM Phase III simulation was completed in October 1995. This phase focused on issues arising from transitioning RVSM-approved aircraft in the WATRS portion of the NAT Region under ZMA control (refer to Figure 3). Aircraft eventually traversing through WATRS airspace would be permitted to exit or enter the MNPS airspace using RVSM rules, and the associated transition would occur within radar coverage provided by ZMA.

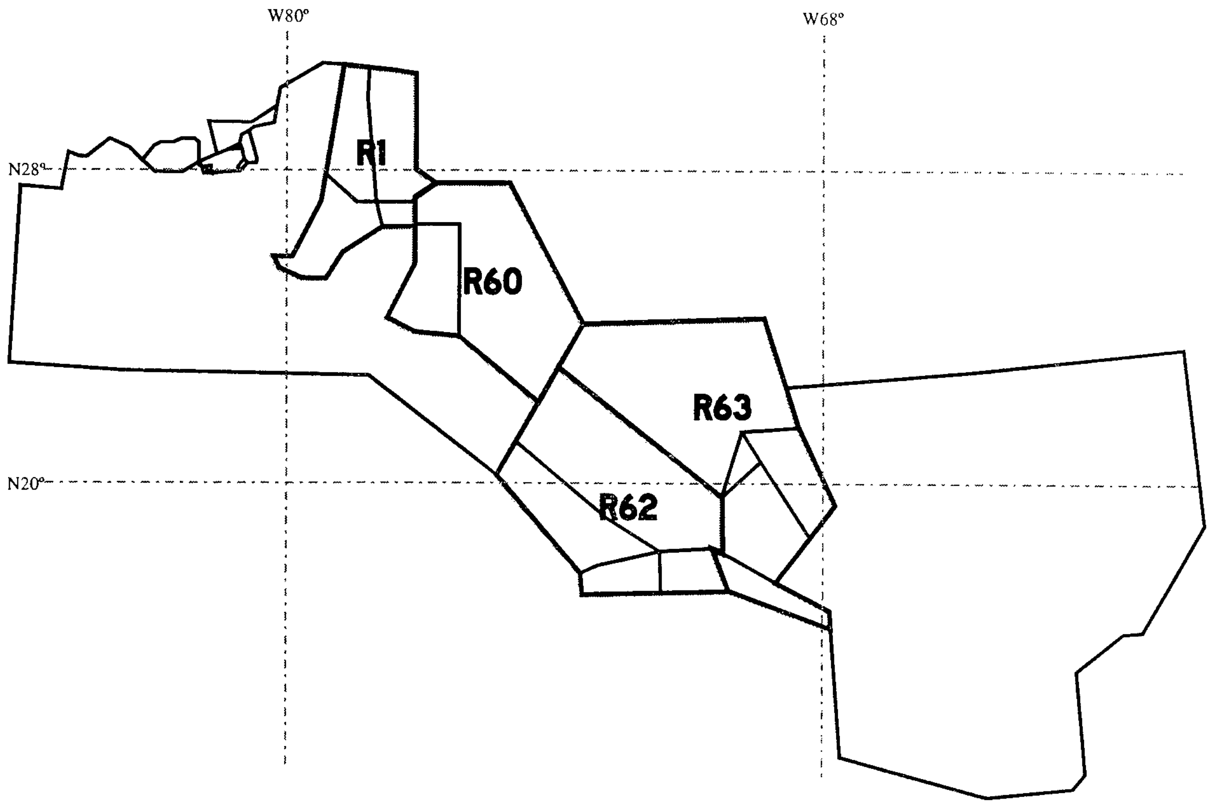

Figure 3. RVSM transition airspace used for Phase III simulations.

During the planning stage of Phase III, ZMA, in conjunction with ZNY, initiated steps to reconfigure the ZMA portion of WATRS airspace. Refer to Appendix A for close-ups of the individual sectors used in the simulation. These changes were not put into effect until after the simulation was completed. The reconfiguration was assumed to result in the alleviation of controller workload by reducing the quantity of aircraft that would be vectored. The reconfiguration was not dependent on the use of RVSM. ZMA personnel conveyed that various other projects were also under way to reconfigure their airspace.

Even though ZMA personnel anticipated changes in the airspace, they felt that it was an appropriate time to conduct the simulation. The Airspace and Procedures Branch, ZMA-530, and the NSC program agreed to the following:

a. Studying RVSM under the configuration at the time of the simulation would provide valuable information that would be applicable regardless of airspace configuration.

b. The simulation would provide data that would be beneficial when making near-term airspace design and procedural changes while considering the future implementation of RVSM.

c. Rescheduling the Dynamic Simulation (DYSIM) Laboratory and all the participants and support personnel would have been very difficult.

d. Contract dollars were already obligated to support the simulation and funding was available.

The decision to conduct the simulation on schedule was financially responsible.

1.2 Purpose

The long range forecast for the NAT Region estimates that air traffic will double by the year 2010[6]. The reduction of vertical separation in the MNPS airspace, NAT Region, between FL 290 and FL 410 inclusive, would theoretically accommodate such a projected increase in air traffic. This enhancement in system capacity would provide for a more efficient use of the available airspace and result in significant improvements in flight economy.

The most difficult problem with operating under RVSM in the MNPS airspace will probably be the transition of aircraft to CVSM. Additionally, the procedures for transition may differ based upon the geographical restrictions. Therefore, ATC procedures for the various RVSM transition areas within the NAT Region and adjacent ICAO Regions need to be defined prior to the implementation of RVSM. Accordingly, this simulation evaluated procedures used by controllers when transitioning aircraft to and from RVSM and from and to CVSM.

This simulation had two objectives. The first objective was to study the feasibility of transitioning RVSM aircraft in the identified geographical areas and to identify problems associated with that transition. The second objective was to address changes in controller workload caused by potential increased flight operations. Part of the second objective was to study the impact of weather-related problems and contingencies that could cause aircraft deviations on controller workload.

The RVSM simulation and associated activities were designed to provide Air Traffic organizations, especially the International Procedures Branch (ATP-140), with the vital, human performance information needed to define RVSM implementation procedures. This simulation represented a critical step by Air Traffic Service (ATS) in assessing current and projected ZMA oceanic ATC system capabilities. The results of this study were closely coordinated and shared with all NAT ATC provider states to help facilitate the development of a unified implementation plan.

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[6]Agenda Item 2, Working Paper 131 presented at the Limited North Atlantic (COM/MET/RAC) Regional Air Navigation Meeting held in Cascais, Portugal, in November 1992.

2. Method

RVSM Phase III was conducted in the ZMA DYSIM Laboratory from October 16 through 27, 1995. The simulation occurred between 19:00 Zulu and 02:00 Zulu for 10 working days, exclusive of the weekends. The immediate physical environment realistically simulated the ZMA radar sectors R60, R62, R63, and R1, including the available control equipment and communication interfaces.

This project incorporated real-time ATC simulations designed to evaluate workload when controllers provided separation and other ATC services in designated domestic oceanic radar-controlled transition airspace. Phase III allowed for the transition of RVSM-approved aircraft to and from RVSM and from and to CVSM standard in the WATRS portion of ZMA airspace. The transition occurred when RVSM-approved aircraft entered the mostly radar-controlled sectors R60, R63, or R1.

The RVSM simulation adhered to the following international guidelines as a basis for developing each simulation scenario:

a. RVSM was affected coincident with MNPS airspace and in defined transition areas.

b. The transition to and from reduced CVSM was affected in transition areas.

c. The transition areas

   1. were defined as Class A airspace; accordingly, aircraft proceeding to and from MNPS airspace were authorized to transition to and from 1000 ft VSM;
   2. were contained within horizontal limits determined by provider states, either individually or in conjunction;
   3. were adjacent to, overlapping with, or contained within MNPS airspace;
   4. were within radar coverage using direct controller/pilot communications wherever practical; and
   5. were contained within the vertical limits of FL 290 to FL 410, inclusive.

d. When operating within transition areas, RVSM was applied between aircraft approved for such operations (refer to Section 1) when transiting to and from MNPS airspace.

In addition, NSC worked with ZMA personnel and DYSIM training specialists to further develop experimental guidelines. These included sector configurations, run time, controller staffing, number of aircraft per scenario (which was sometimes limited by DYSIM operator capabilities), and contingencies.

Each simulation parameter was designed to enable valid comparisons between current CVSM operations and planned RVSM operations. RVSM Phase III investigated the following and relied on responses from the associated questions for analysis of

a. changes in controller workload levels as impacted by RVSM operations,

b. operational issues associated with RVSM operations,

c. operational difficulties associated with controllers' ability to transition aircraft to and from RVSM within radar coverage, and

d. other issues related to reverting from RVSM rules to CVSM rules such as the

   1. most frequently occurring questions or problems, and

   2. occurrences under special scripted events (unreliable radar coverage and adverse weather conditions).

2.1 Participants

Fifty-six currently certified controllers from ZMA participated in this simulation. Thirty-eight controllers staffed control positions and 18 controllers participated as technical observers (T/Os).

Five DYSIM training specialists from the Washington Consulting Group (WCG) staffed two pseudo-pilot positions. Another WCG specialist staffed a remote controller position. ACT-530 and ACT-540 provided five additional support personnel from the FAA William J. Hughes Technical Center.

2.1.1 Background Survey

A background survey (refer to Appendix B) was conducted to collect basic demographic data and information about the participants' opinions regarding high workload situations. Data from this survey were used as a baseline for comparison with survey responses collected throughout the simulation. Appendix C contains a summary of background information.

The average age of the controllers and T/Os was 33. The controllers had an average of 6.6 years of ATC experience and an average of 4.3 of those years at full performance level (FPL). The T/Os had more experience overall with an average of 8.6 years of ATC experience and an average of 6.1 of those years at FPL. Fifteen of the 18 T/Os also had previous experience training controllers. Forty-five of the 56 participants had controlled traffic for ZMA only. Figures 4, 5, 6, and 7 depict questionnaire responses.

Question 6 of the Background Information Form asked participants to list factors affecting safe and expeditious traffic flow in their current ATC environment. Figures 4 and 6 display the frequency of these responses. Fifteen participants responded to questions for Area 2, and 41 participants responded to questions for Area 4. "Comm. Failure" consists of frequency problems and outages and aircraft radio failure. "Control Issues" encompasses concerns such as lack of available altitudes, excessive coordination, and aircraft failing to report over fixes. "Foreign Language" refers to difficulties communicating with foreign pilots and facilities. "Other" includes anything that does not fit into the previously mentioned categories such as military operations, emergencies, and hijackings. "Radar & Equipment" includes radar outages, blind spots in the radar coverage, equipment failure, and navigation aids. For Area 2, Control Issues was the most frequently listed factor. In Area 4, more participants listed Radar & Equipment as a factor affecting safe and expeditious traffic flow.

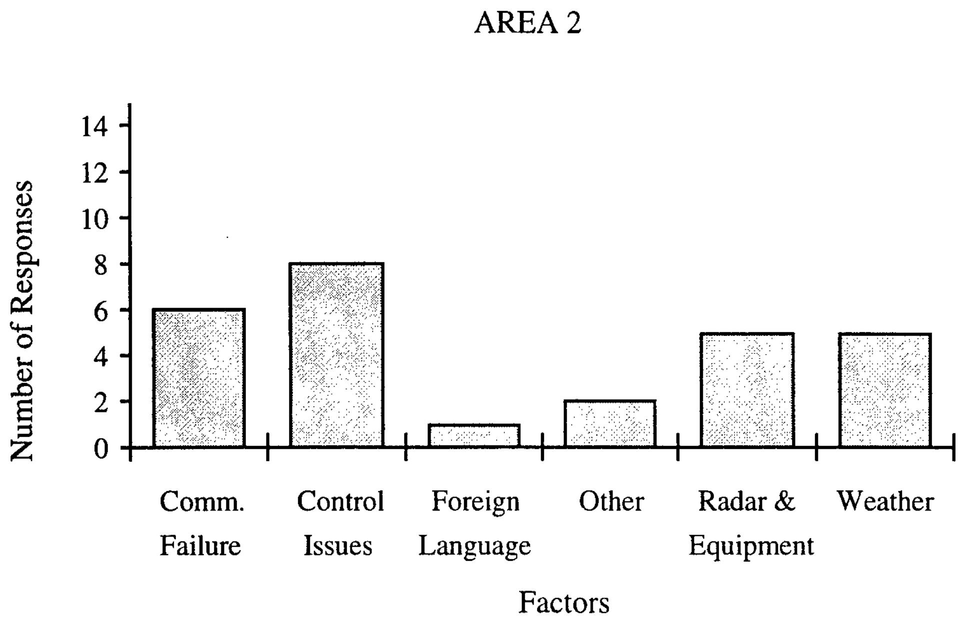

Figure 4. Factors affecting safe and expeditious traffic flow in Area 2.

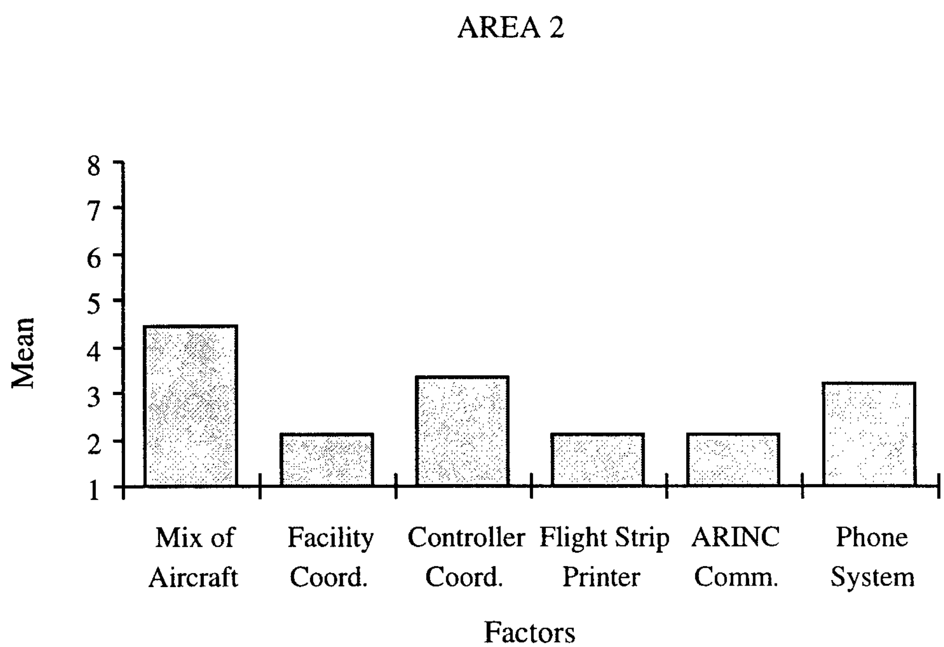

Figure 5. Mean rating of factors contributing to high workload in Area 2.

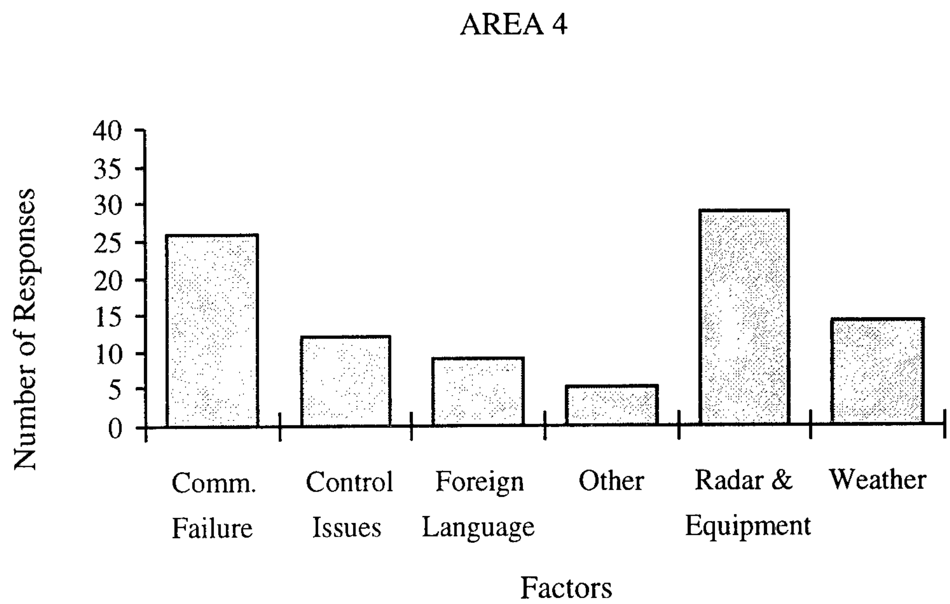

Figure 6. Factors affecting safe and expeditious traffic flow in Area 4.

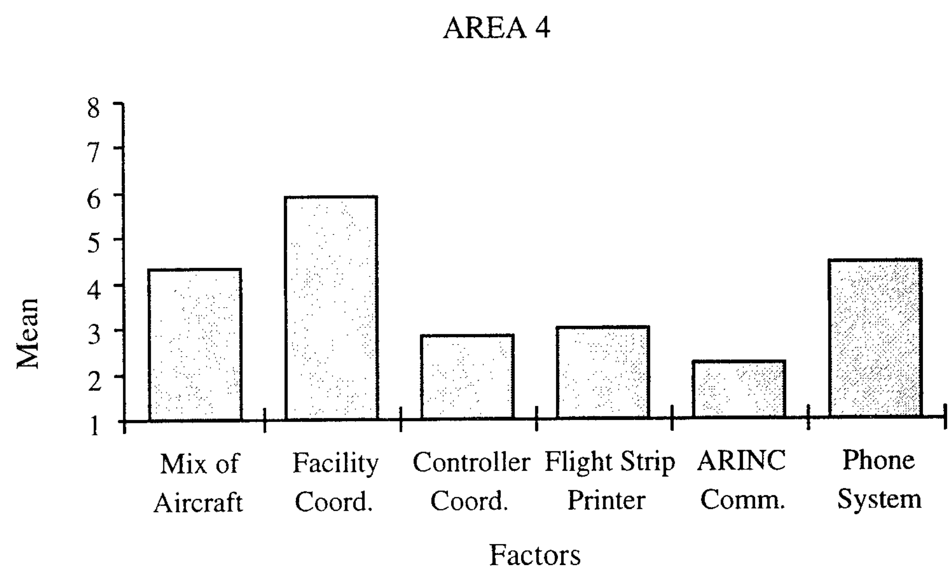

Figure 7. Mean rating of factors contributing to high workload in Area 4.

On a scale from 1 to 8, controllers and T/Os rated seven aspects of ATC for their contribution to high workload levels in the current ATC environment. Figures 5 and 7 show the mean rating for each factor by area. For Area 2, a mix of aircraft performance/characteristics had the highest average rating ($M = 4.4$, $SD = 2.0$). Coordination with foreign facilities had the highest average rating for contribution to workload in Area 4 ($M = 5.9$, $SD = 1.5$).

2.2 Equipment/Configuration

2.2.1 DYSIM Laboratory

The ZMA DYSIM Laboratory provided controllers with a realistic simulated radar environment. All the planned scenarios were stored as files on a DYSIM tape. Simulated (SIM) radar targets were generated using the Simulation Start action on the aircraft in the DYSIM files. A SIM target represents the radar trails of a maneuvering aircraft.

The Multiple Radar Processing function of the National Airspace System (NAS) generated and processed primary and beacon radar data for each SIM target in a manner similar to normal radar data. The SIM flight data block contained the SIM flight identification, magnetic heading, beacon code, and altitude. The position of the SIM radar data was automatically updated approximately every 10 seconds.

The SIM radar targets maneuvered automatically based on route segments from a flight plan and by operator inputs into a Computer Readout Display (CRD) to depict actual aircraft operations. The CRD allowed the pilot to alter 10 aspects of an aircraft flight (altitude, routing, rate of climb, etc.). The result was a totally simulated flight that could exercise almost all functions as if there was a paired flight plan and flight data processing with flight progress strip preparation capability.

2.2.2 Voice Communication System

The voice communication was a Robert Thomas Smith (RTS) Systems Model CS9500 Digital Intercom System. The RTS CS9500 is a programmable intercommunication system that maintains high quality speech characteristics utilizing a 4-wire, central, non-blocking matrix design. Voice communication key panels were attached to the matrix via RJ-11 cabling. An MS-DOS-based package called CSEdit, operating on a 486 laptop PC connected to the matrix through the serial communication port, provided system programming.

The controllers used voice communication key panels that provided communications functionality comparable to the control floor exclusive of a shout line. Party lines were used to emulate radio frequencies between controllers and pilots. Point-to-point communications were used for communication between adjacent sectors and centers. The matrix was programmed to meet the specifications required by the various simulation configurations.

2.2.3 Audio and Video Recording Rack

The audio and video equipment and the voice communication matrix were mounted in two mobile equipment racks. Each rack was specifically designed to protect sensitive equipment during shipping and provided work surfaces during the simulation.

Video data collection consisted of three separate camera views recorded from black and white, low-light micro-cameras. Two cameras recorded each sector individually, and the third recorded an overall view of the controller plan view display (PVD) row. The video was recorded in Super

VHS format on 2-hour tapes stamped with National Television System Committee linear time code for synchronous playback purposes.

Eight separate audio signals were recorded from wireless microphones worn by each controller and four audio channels recorded directly from the communication system. The audio signals were mixed on a Tascam M2516 audio mixing board and recorded on the Hi-Fi audio channels of the videotapes according to the corresponding camera views. They were also recorded separately onto a 16-track 1/2" audiotape for backup purposes or to allow audio signal isolation.

2.3 Scenarios

A DYSIM training specialist with previous ZMA ATC experience developed each scenario. These scenarios were based on flight plans extracted from Data Analysis and Reduction Tool (DART) runs of System Analysis and Recording (SAR) tapes from both ZMA and ZNY.

Table 1 describes the 11 one-hour scenarios run during Phase III. Scenarios varied according to the following parameters: separation minima, sector configuration, number of controllers and aircraft at each sector, and contingencies. Contingency problems consisted of simulated radar outages (Nassau radar in R60 and Grand Turk radar in R63) or adverse weather conditions. Each scenario was named with a number and a letter. Scenarios with the same number had the same number of aircraft, control positions, and sector configuration. A C, R, or E follows these numbers indicating whether the separation was CVSM, RVSM, or RVSM with contingencies (RVSM-E), respectively.

Table 1. Summary of Scenarios

Scenario Name	Separation Minima	Sector on PVD 93	PVD 93 Control Positions	Sector on PVD 94	PVD 94 Control Positions	Contingency
1R	RVSM	R63	R, D	R60	R, D	-
1C	CVSM	R63	R, D	R60	R, D	-
1E	RVSM	R63	R, D	R60	R, D	Weather/Radar
2R	RVSM	R62/R63	R, D	R60	R, D	-
2C	CVSM	R62/R63	R, D	R60	R, D	-
2E	RVSM	R62/R63	R, D	R60	R, D	Weather/Radar
3R	RVSM	R60/R62/R63	R, D	R1	R, D	-
3C	CVSM	R60/R62/R63	R, D	R1	R, D	-
4R	RVSM	R62/R63	R, D, A	-	-	-
4C	CVSM	R62/R63	R, D, A	-	-	-
4E	RVSM	R62/R63	R, D, A	-	-	Weather/Radar

All scenarios were run in the DYSIM Laboratory using PVDs 93 and 94. The sectors in question (e.g., R1, R60, R62, and R63) were configured on each PVD to match the configuration on the control floor.

ZMA sector density analysis reports and input from Area 2 and Area 4 specialists determined the number of aircraft in each scenario. DYSIM operator input capabilities limited the maximum number of aircraft per scenario. It was determined that the number of aircraft required to represent a busy day was

- 35-40, if all three positions [i.e., Radar (R), Hand-Off (D), and Associate (A)] were staffed; and
- 25-30, if two positions (i.e., R and D) were staffed.

Between 10% and 20% of the aircraft in each scenario filed flight plans at RVSM altitudes. This percentage was based on aircraft that would be eligible for RVSM at the time of the simulation. Table 2 lists the number of scripted pilot events and the number of aircraft in each scenario.

Table 2. Frequency of Pilot Events

PVD[a]	93	94	93	94
	Pilot Events		Number of Aircraft	
Scenario				
1R	6	6	27	27
1C	6 or 7	6	27	27
1E	6	6	29	27
2R	6	6	27	26
2C	6 or 7	6	27	26
2E	6	6	29	25
3R	6 or 7	6	27	28
3C	6 or 7	6	27	28
4R	6 or 7	5 or 6	39	-
4C	6 or 8	6	39	-
4E	6 or 7	6	39	-

[a] Refer to Table 1 for description of PVD 93 and 94

2.4 Experimental Procedures

Table 3 lists the daily schedule for the 10 days of simulation including scenario name, date, run time, and contingency. Five scenarios were run daily except for the last day, which included four. Scenarios were assigned randomly except for the last two runs of the first 5 days. Due to sector configurations on the control room floor, it was imperative that Scenarios 3C and 3R be run at the end of the evening. Figure 8 indicates the laboratory configuration for Scenarios 1, 2, and 3. Figure 9 indicates the laboratory configuration for Scenario 4.

Table 3. Scenario Schedule

Day Date	Run ZULU Time	Run ZULU Time	Run ZULU Time	Run ZULU Time	Run ZULU Time
1 10/16/95	1R 19:15 - 20:15	1C 20:40 - 21:40	1E (Radar) 21:52 - 22:49	3C 00:05 - 01:03	3R 01:36 - 02:19
2 10/17/95	2R 19:12 - 20:13	2C 20:31 - 21:30	2E (Weather) 21:44 - 22:44	3R 23:47 - 00:46	3C 01:02 - 01:59
3 10/18/95	4R 19:05 - 20:05	4E (Radar) 20:24 - 21:25	4C 21:40 - 22:40	3R 23:46 - 00:42	3C 01:00 - 02:00
4 10/19/95	4C 19:02 - 20:02	4R 20:20 - 21:19	4E (Radar) 21:33 - 22:33	3C 23:55 - 00:52	3R 01:15 - 02:02
5 10/20/95	1R 19:00 - 20:00	1C 20:15 - 21:15	1E (Radar) 21:25 - 22:25	3C 23:37 - 00:36	3R 00:47 - 01:45
6 10/23/95	2R 19:04 - 20:03	2C 20:21 - 21:21	4E (Radar) 21:41 - 22:41	4C 23:43 - 00:43	4R 01:00 - 02:00
7 10/24/95	2C 19:02 - 20:02	2R 20:20 - 21:20	4R 21:44 - 22:44	4E (Weather) 23:50 - 00:50	4C 01:07 - 02:07
8 10/25/95	1C 18:59 - 19:59	1R 20:14 - 21:14	1E (Weather) 21:32 - 22:31	4C 23:38 - 00:38	4R 00:55 - 01:55
9 10/26/95	1R 18:44 - 19:44	2E (Radar) 19:59 - 20:29	1C 21:15 - 22:15	2C 23:11 - 00:11	2R 00:25 - 01:25
10 10/27/95	1C 18:58 - 19:58	2C 20:10 - 21:10	1R 21:25 - 22:25	2R 23:12 - 00:12	a

[a]Time allotted in case of system failures.

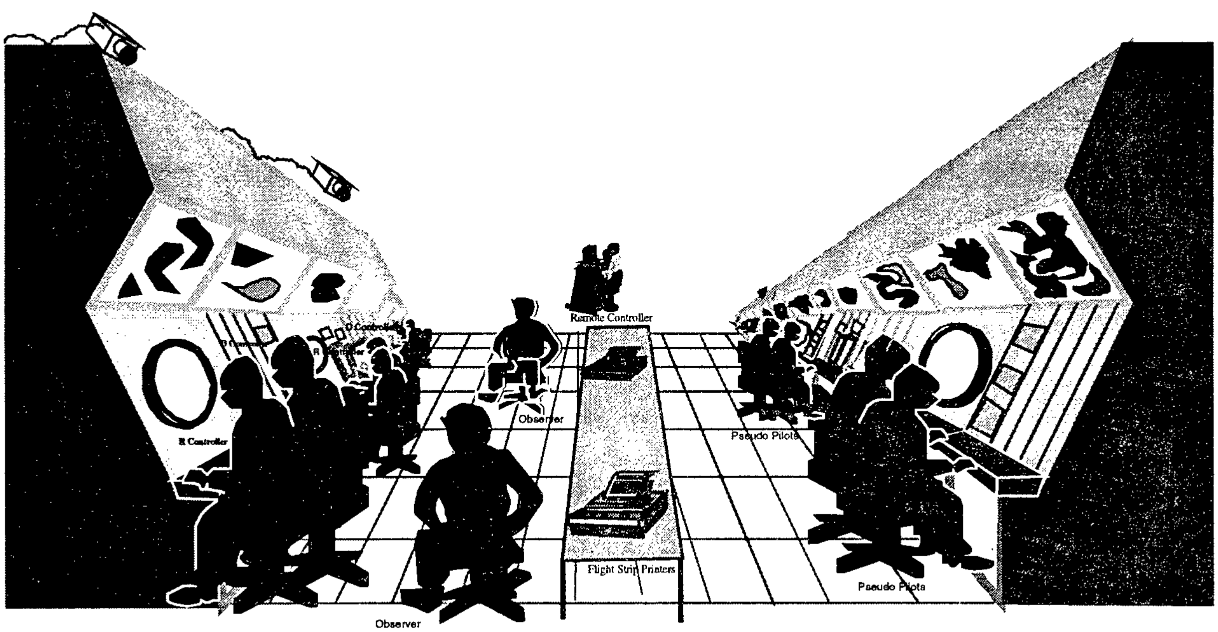

Figure 8. DYSIM Laboratory configuration for Scenarios 1, 2, and 3.

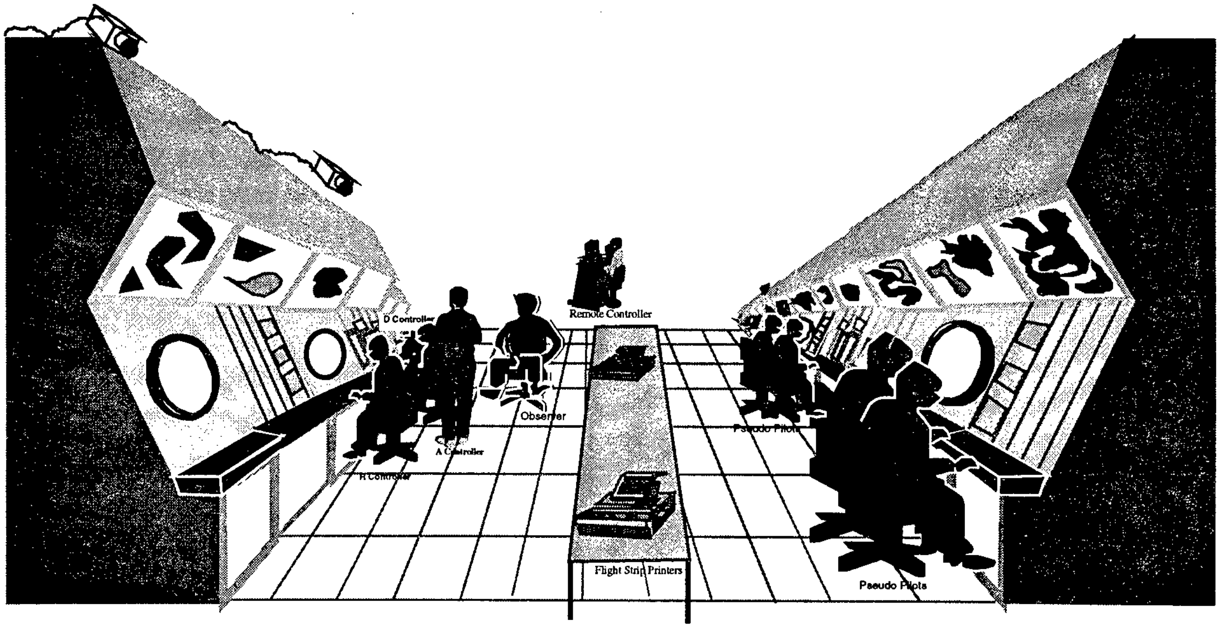

Figure 9. DYSIM Laboratory configuration for Scenario 4.

For one-half hour before the start of the first run of the day, participants received a briefing and became familiar with the communications equipment. During the briefing, controllers were instructed to apply all the current ATC standards with the addition of RVSM. For purposes of the simulation, controllers were also instructed to adhere to the following guidelines set forth by ZMA-530:

a. RVSM transitions must take place in the WATRS portion of a transition sector except for R1.

b. R1 must send aircraft to ZNY at RVSM altitudes but will not receive them from ZNY at RVSM altitudes.

c. Sectors R1, R60, and R63 are the only RVSM transition sectors.

d. Aircraft flying in San Juan airspace do not need to be transitioned before entering and exiting ZMA airspace during the simulations. (It is assumed that San Juan will also be using RVSM).

In addition, controllers were instructed to allow an aircraft to operate at RVSM altitudes if

a. it was a B747, B74F, B767, B757 (American Trans Air or Iceland Air), DC-10, MD-11, L-1011, G-2, G-3, G-4, CL-60, DA-50, DA-90, or HS-25; and

b. it was departing or arriving from Europe, Africa, or Greenland, or it was flying airway R759, A554, G431, R763, B646, G437, A699, or A700 from NY.

Because the exact fleet of aircraft that will be RVSM eligible has not yet been determined, these criteria were established from a list of RVSM-approved operators and aircraft. Aircraft were on this list if they were approved by their state of registry. For future reference or updates, this list is maintained in a central data base at the United Kingdom Civil Aviation Authority in London, England.

2.4.1 Controller Assignment

A different group of Area 2 and Area 4 controllers were scheduled to participate in the simulation each day. [7] None of the controllers worked traffic for the same scenario more than once. Once a controller was assigned to a control position (i.e., R, D, or A) at a particular sector, he or she remained at that control position and sector for all variations of that scenario (i.e., CVSM, RVSM, RVSM-E). The same was true for the T/Os.

The Area Supervisors determined which control position each controller worked and which controllers participated as T/Os. For example, Area Supervisors approved controller 3031 to work the R position and controller 1742 to be a T/O. On the first day, each was assigned to sector 60 during Scenario 1R. They remained at sector 60 observing and controlling the R position for Scenarios 1C and 1E.

2.4.2 Data Collection

All participants anonymously filled out the Background Information Form and Post-Run Questionnaire, reported interval workload values (refer to Appendix B)[8], and participated in recorded debriefing sessions. SAR data were recorded for each run. For completeness, each run was also audio and video recorded. Simulation data were collected via

a. automated recording of Host data via SAR tapes,

b. real-time observations of critical controller actions (operational errors and deviations) recorded by T/Os throughout each simulation run,

c. real-time interval workload ratings[9] made by the T/Os,

d. real-time interval workload ratings obtained by having support personnel prompt a verbal report from all controllers throughout each run, [10]

e. participant responses to Post-Run Questionnaires and structured interviews conducted after each simulation run, and

f. support personnel tabulations of controller communications.[11]

Questions that required participant ratings were based on an 8-point scale. For workload ratings, 1 indicated very low workload and 8 indicated very high workload. For other ratings, 8 indicated

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[7] Due to schedule changes, some people participated more than 1 day.

[8] When an A controller was present, an additional form was provided. The form was not included in Appendix B because the questions are the same.

[9] Four interval ratings obtained, one rating every 15 minutes.

[10] This procedure, Air Traffic Workload Input Technique (ATWIT), is FAA-validated and used for the continual assessment of controller workload.

[11] A communication was measured every time a controller verbalized a message into his or her head set.

better performance. Table 4 defines each subjective measure. Table 5 defines the analyzed SAR messages.

Some SAR data were not recorded because of operator recording errors. These errors were not discovered within 15 days of the recording date, therefore, the data were not recoverable. Table 6 lists the scenarios with partial or no data. Partial SAR data were used whenever it was applicable.

Table 4. Subjective Dependent Measures

Measurement	Low Rating (1)	High Rating (8)
Maintenance of Separation - Adhered to separation standards as specified in ATP 7110.65	Could not maintain separation	Easily maintained separation
Workload	Easily completed all tasks accurately	Could not complete all tasks
Communication - Used ATP 7110.65 specifications	Rarely followed ATP 7110.65 specifications	Always followed ATP 7110.65 specifications
Coordination - Provided complete and correct information for clearances and estimates in a timely manner	Frequently gave incorrect or incomplete information	Always gave correct information
Maintenance of Situational Awareness - Addressed all aspects of airspace and aircraft	Could not maintain awareness	Easily maintained awareness
Priority of Actions - Issued control instructions in prioritized, structured manner as specified in ATP 7110.65	Did not follow specified priority	Always followed specified priority
Flight Strip Management - Marked strips accurately while performing other tasks; kept strips current	Could not maintain strips	Easily maintained strips
Computer Entry - Accurately input control commands into key panel	Had great difficulty inputting commands	Easily and accurately input commands

Table 5. Objective SAR Dependent Measures

Message	Definition
ACCPT	A received/entered message has met all NAS message checking criteria
AM	Input to amend a flight plan
ERROR	Generated when the computer determines that a field or combination of fields in an input message violates the acceptance criteria for that particular message
QF	Flight plan readout request, similar to a 'FR' entry
QN	Accept handoff, initiate handoff, data block offset, force data block, emergency airport display
QP	Distance reference indicators, point out, request/suppress data blocks
QQ	Interim altitude
QR	Reported altitude
QT	Assigned altitude, coast track, track
QU	Track re-route, route display
QX	Drop tracks only
QZ	Assigned altitude, accept handoff, initiate handoff, data block offset, force data block, emergency airport display
REJCT	Message returned when the computer program determines an input message to be in error
SR	Requested the printing/reprinting at the desired position of one flight progress strip for the specified flight

Table 6. Scenarios With Missing Data

Date	Scenario	Amount of Data
10/17	2C	Partial
10/17	2E	Partial
10/18	4R	None
10/18	4E	Partial
10/18	4C	Partial
10/18	3R	Partial
10/18	3C	Partial
10/19	4C	None
10/20	3C	Partial
10/27	2R	Partial

2.5 Simulation Fidelity

Question 3 of the Post-Run Questionnaire addressed simulation realism. Controllers and T/Os rated three aspects of the simulation for realism: traffic flow, physical environment, and taskload. A significant difference, $F(4, 298) = 4.44$, existed between ratings given for traffic flow for scenarios in Area 2 (sector R1) compared to scenarios for Area 4 (sectors R60, R62, R63). Controllers and T/Os gave average ratings of 6.28 through 6.41 ($SD = 1.50$) for the Area 4 scenarios. A significantly lower average rating of 5.10 ($SD = 1.70$) was reported for Area 2.

Reasons for lower ratings in Area 2 included not enough departures, high volume of non-radar traffic, and high volume of crossing traffic. It should be noted that the simulation was designed to focus on the increased non-radar and crossing traffic that may result from RVSM implementation.

No statistically significant differences existed between scenarios for physical environment ratings. The average rating reported for physical environment was 6.84 (SD = 1.14). The most common reasons for lower ratings were differences in the communication system, lights were too bright, and improper location of the A position.

Statistically significant differences were found between average taskload ratings reported for the two Areas, $F(4, 296) = 2.42$. Average ratings of 6.24 through 6.50 (SD = 1.36) were reported for Area 4 scenarios. A statistically significant lower average rating of 5.66 (SD = 1.52) was reported for Area 2. The most commonly reported reason for a lower rating was the lack of weather deviations. Scenarios for Area 2 did not include any simulated adverse weather.

3. Results

A comparative analysis was conducted between CVSM and RVSM (e.g., 1C vs. 1R) and between RVSM and RVSM-E (e.g., 1R vs. 1E). CVSM was not compared to RVSM-E because it could not be concluded if differences were due to RVSM or contingency operations.

Controller and T/O data were analyzed independently for each scenario. For both controller and T/O data, each dependent variable was analyzed with a repeated measures design using *separation* as the within subjects variable and *sector* and *position* as the between subject variables. All tests were performed with a significance level of $\alpha = 0.05$. Preliminary analysis included all high-level interactions. If the interactions did not reach significance, they were discounted, and the analysis was conducted again without them. It should be noted that all T/O data are expert opinions and reflects the T/O's perception of the controller's experiences. The means and standard deviations of all the subjective and objective measures are given in Appendix D.

Interval workload data were analyzed with number of aircraft as a covariant. The choice of the number of aircraft as a covariant was based on prior literature, indicating a strong relationship between workload and the number of aircraft (Costa, 1993; Hurst & Rose, 1978 a, b; Kopardekar, 1995; Laurig, Becker-Biskaborn, & Reiche, 1971; Stein, 1985; Zeier, 1994).

If a variable was found to be statistically significant, its practical significance was assessed. For purposes of this analysis, the 8-point scale was segregated into three levels: low, moderate, and high. If the variable averages remained within the low end of the scale, the variable was considered not affected by the new condition at a level that had any real world application. In other words, if a statistically significant variable showed a change at the moderate or high level, it was considered practically significant. A workload result was considered practically significant if at least one average rating was above 2.99. All other subjective measures were practically significant if at least one average rating was less than 6.01.

The first section discusses operational errors and deviations recorded during the simulation. Next, a comparative analysis of CVSM vs. RVSM, then RVSM vs. RVSM-E is presented. Each Post-Run Questionnaire parameter was analyzed separately. In the final section, the effects of increased traffic and safety issues are discussed.

3.1 Operational Errors

Figures 10, 11, 12, and 13 display the number of deviations and operational errors recorded by the T/Os for each scenario. Symbols represent the total number of operational errors/deviations recorded per run. Solid squares represent operational errors, deviations are solid triangles, solid diamonds indicate an equal number of operational errors and deviations, and open squares indicate that no operational errors or deviations were recorded. Refer to Appendix E for a detailed description of the data presented in the figures.

Figure 10 displays results from Scenario 1. As shown in the figure, two deviations were made in sector R60 during CVSM. These were made by the same control team and were related to flight strip management. One operational error was recorded for sector R63, and it related to lateral separation. No operational errors or deviations were recorded during RVSM. During RVSM-E conditions, two operational errors were made by the same team pertaining to lateral separation. A different team also had a lateral separation error. Another team made one deviation related to flight strips.

Figure 11 shows that no operational errors or deviations were made during CVSM and RVSM for Scenario 2. During RVSM-E, two teams each made one operational error related to lateral separation in sector R60. No operational errors or deviations were recorded for sector R62/63 during RVSM-E.

Figure 12 reveals the operational errors and deviations made during Scenario 3. The same control team made two deviations in sector R60/62/63 during CVSM. One operational error related to lateral separation was also made by a different team. No operational errors or deviations were recorded for sector R1 during CVSM. The same control team that had the deviations during CVSM made one deviation during RVSM. In sector R1, a different control team made two operational errors related to separation. Another team made an operational error related to coordination and separation for sector R1.

Figure 13 displays results from Scenario 4. The figure shows that during CVSM, one team made three operational errors and two other teams made one operational error each. All errors were related to separation. During RVSM, one team made two errors. One error was an RVSM violation and the other was related to separation. Two different teams made one operational error and deviation each. For both teams, the operational error related to separation and the deviation related to a failure to coordinate. Another team had one deviation and three operational errors. Two of the errors were RVSM violations and the third was related to separation. The deviation was related to a failure to coordinate. Figure 13 indicates that during RVSM-E, the same team made five operational errors and two deviations. Both deviations were related to a failure to coordinate. All of the errors were related to separation and, specifically, one error resulted from a controller not following the command that was coordinated. Another team, had two RVSM violations that are represented here as operational errors. A different team had at

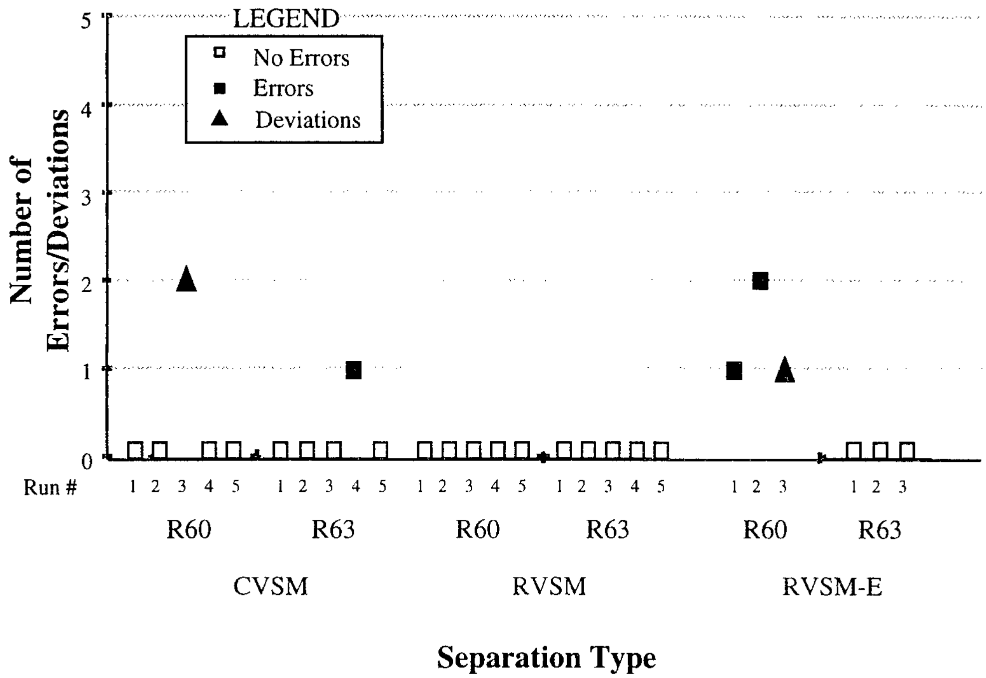

Figure 10. Number of operational errors and deviations for Scenario 1.

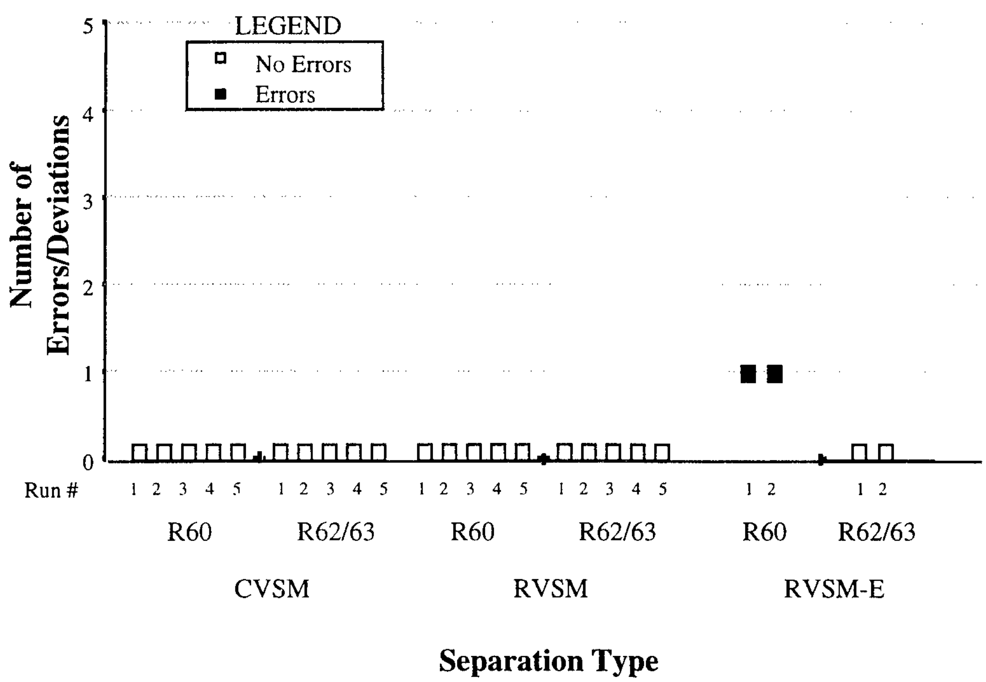

Figure 11. Number of operational errors and deviations for Scenario 2.

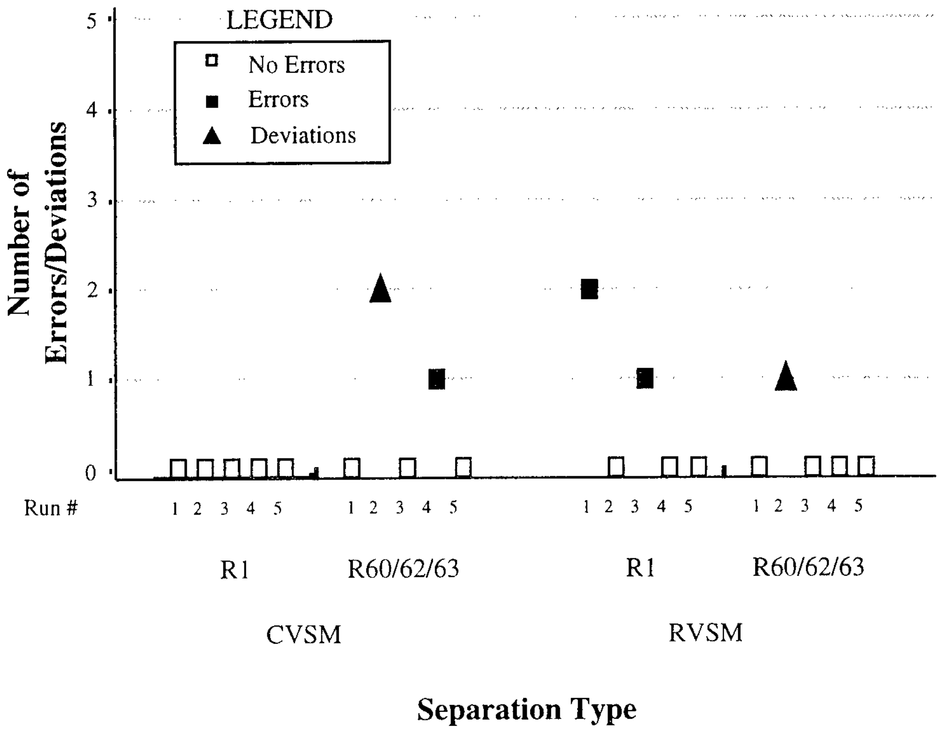

Figure 12. Number of operational errors and deviations for Scenario 3.

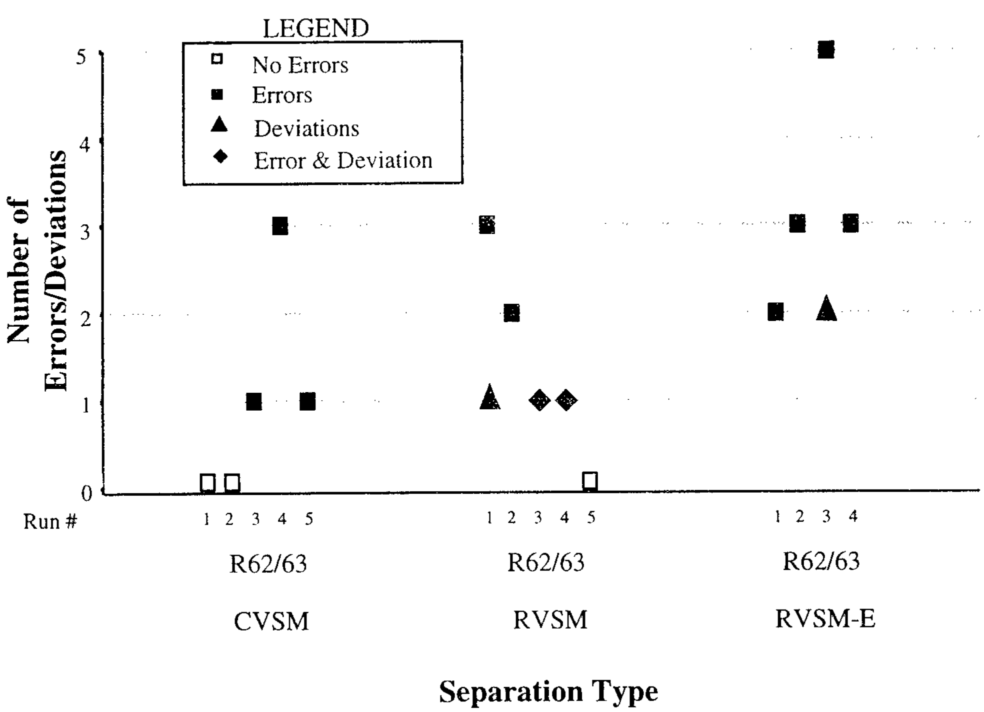

Figure 13. Number of operational errors and deviations for Scenario 4.

least three errors related to separation. The T/O indicated that, for this team, there were too many errors to note them all. Another team also had three operational errors. Two were related to separation and the third was related to a failure to coordinate.

3.2 CVSM vs. RVSM

3.2.1 Maintaining Separation

Analysis of controller and T/O ratings for ability to maintain aircraft separation revealed no significant difference between CVSM and RVSM for Scenarios 1, 2, and 4. The result failed to indicate any impact on maintaining separation due to RVSM.

Controller self-ratings revealed a significant separation by sector interaction for Scenario 3 [$F(1, 16) = 9.02$]. An analysis of self-ratings by sector resulted in a significant difference between RVSM and CVSM for sector R1 [$F(1, 8) = 10.29$]. The average rating was lower for RVSM than CVSM. This was confirmed by T/O ratings, which also had a significant separation by sector interaction for Scenario 3 [$F(1, 18) = 4.42$]. T/O-rated averages also remained relatively constant for sector R60/62/63 but decreased under RVSM for sector R1.

3.2.2 Workload

Controllers and T/Os gave workload ratings at four intervals throughout each run. To supplement these ratings, a post-run workload rating was given at the end of the run. Both of these ratings are discussed for each scenario below.

Scenario 1 self-rated interval workload was significantly different between CVSM and RVSM [$F(1, 75) = 6.26$]. The average workload was lower during CVSM than RVSM. T/O ratings showed a significant sector by separation interaction for Scenario 1 [$F(1, 75) = 6.26$]. An analysis by sector confirmed the controller finding only for sector R63 [$F(1, 37) = 9.10$]. All averages fell below 2.99, therefore, the significance found for the controller and T/O ratings was considered not to be practical.

Analysis showed a significant difference in the self-rated post-run workload between CVSM and RVSM for Scenario 1 [$F(1, 16) = 12.23$]. Both controller averages were below 2.99, therefore, the significance was considered not practical. T/O ratings showed a significant separation by sector interaction for Scenario 1 [$F(1, 16) = 7.38$]. An analysis by sector showed a significant difference in the ratings for sector R63 [$F(1, 8) = 19.60$]. The RVSM average rating for sector R63 was higher than the CVSM average.

Scenario 2 self-rated interval workload was significantly different between CVSM and RVSM [$F(1, 55) = 4.98$]. Both controller averages were below 2.99, therefore, the significance was considered not practical. T/O interval ratings showed no significant difference between CVSM and RVSM. Both measures failed to indicate any practical impact on interval workload for Scenario 2 due to RVSM.

Both self- and T/O-rated post-run workload analyses resulted in no significant difference between CVSM and RVSM for Scenario 2. This result failed to indicate any impact on post-run workload due to RVSM.

Both self- and T/O-rated interval workload analyses resulted in no significant difference between CVSM and RVSM for Scenario 3. This result failed to indicate any impact on interval workload due to RVSM.

Post-run analysis was not consistent with interval workload analysis. Scenario 3 self-rated post-run workload had a significant separation by sector interaction [$F(1, 16) = 11.20$]. An analysis by sector showed that sector R1 workload was significantly different between CVSM and RVSM [$F(1, 8) = 9.80$]. The RVSM average rating was higher than the CVSM average. This was confirmed by T/O ratings which also revealed a separation by sector interaction for Scenario 3 [$F(1, 16) = 5.69$]. Analysis by sector also showed a significant difference in the T/O-rated workload for sector R1 [($F(1, 8) = 7.58$]. Here again, the RVSM average rating was higher than the CVSM average.

Scenario 4 self-rated interval workload was significantly different between CVSM and RVSM [$F(1, 58) = 11.29$]. T/O ratings also showed a significant difference between CVSM and RVSM [$F(1, 58) = 11.68$]. The average interval workload for both the controllers and T/Os was lower for CVSM than RVSM.

The average self-rated post-run workload was significantly different for Scenario 4 [$F(1, 12) = 5.76$]. The RVSM average rating was higher than the CVSM average. Although not significant, the average T/O workload rating for RVSM was also higher than the average T/O rating for CVSM.

3.2.3 Frequency of Communications

For all scenarios, no significant difference was found between CVSM and RVSM for the average recorded number of communications. Results failed to indicate any practical impact on the frequency of controller communications due to RVSM.

3.2.4 Communication Rating

Self- and T/O-rated values for communication were analyzed and no statistically significant difference was found between CVSM and RVSM for Scenarios 1, 2, and 4. These results failed to indicate any impact on controller's ability to follow ATP communication specifications due to RVSM.

Scenario 3 self-ratings showed a significant separation by sector interaction [$F(1, 16) = 6.45$]. Analysis by sector revealed a significant difference between RVSM and CVSM for sector R1 [$F(1, 9) = 4.97$]. Both controller average ratings were above 6.01, therefore, the significance was considered not practical. T/O ratings also showed a significant separation by sector interaction for Scenario 3 [$F(1, 16) = 5.24$]. Analysis by sector confirmed a significant RVSM effect for sector R1 [$F(1, 8) = 5.40$].

3.2.5 Coordination Rating

Analysis of T/O- and self-rated values for coordination showed no statistically significant difference between CVSM and RVSM for Scenarios 1, 2, and 4. These results failed to indicate any impact on controller coordination due to RVSM.

Analysis of self-ratings showed that Scenario 3 had a significant separation by position interaction [$F(1, 16) = 8.38$]. An analysis by position showed a significant separation effect for the R position [$F(1, 8) = 6.45$]. The average R position rating decreased from CVSM to RVSM. Both controller average ratings were above 6.01, therefore, the significance was considered not practical. T/O ratings resulted in no significant difference between CVSM and RVSM for Scenario 3. Both controller and T/O measures failed to indicate any practical impact on controller coordination due to RVSM for Scenario 3.

3.2.6 Situational Awareness

Analysis of controller and T/O ratings for situational awareness showed no statistically significant difference between CVSM and RVSM for Scenarios 1, 2, and 4. These results failed to indicate any impact on controller situational awareness due to RVSM.

Scenario 3 self-rated analysis revealed a significant separation by sector interaction [$F(1, 16) = 6.03$]. The average rating decreased from CVSM to RVSM for sector R1. Although not significant, the same trend was observed for T/O ratings.

3.2.7 Priority of Actions

Self- and T/O-rated values for priority of actions were analyzed and revealed no significant difference between CVSM and RVSM for Scenarios 2, 3, and 4. These results failed to indicate any impact on the controller's ability to issue instructions in a prioritized manner due to RVSM.

Self-rated values for Scenario 1 showed a significant separation by position interaction [$F(1, 16) = 5.12$]. Analysis by control position revealed a significant separation effect for the R position only [$F(1, 7) = 5.89$]. Both controller average ratings were above 6.01, therefore, the significance was considered not practical. T/O ratings indicated no significant difference between CVSM and RVSM for Scenario 1. Both controller and T/O measures failed to indicate any practical impact on priority of actions for Scenario 1 due to RVSM.

3.2.8 Flight Strips

Analysis of self- and T/O-rated values for flight strips showed no significant difference between CVSM and RVSM for Scenarios 2, 3, and 4. These results failed to indicate any impact on the controller's ability to manage flight strips due to RVSM.

Controller self-ratings had a significant separation by position interaction for Scenario 1 [$F(1, 16) = 5.94$]. An analysis by control position showed that only the R control position had a significant separation effect [$F(1, 8) = 8.26$]. The average decreased from CVSM to RVSM for the R controller. T/O-rated values did not confirm this interaction. Instead a significant separation by sector interaction was found for Scenario 1 [$F(1, 16) = 5.95$]. Analysis by sector showed that sector R63 had significantly different flight strip ratings between CVSM than RVSM [$F(1, 8) = 8.79$]. The average rating for CVSM was higher than the average for RVSM.

3.2.9 Computer Entry

Analysis of self-rated and T/O-rated values for computer entry resulted in no significant difference between CVSM and RVSM for Scenarios 2, 3, and 4. These results failed to indicate any impact on the controller's ability to accurately input control commands due to RVSM.

T/O-rated values for Scenario 1 showed a significant separation by sector interaction [$F(1, 16) = 10.08$]. An analysis by sector revealed that only sector R60 had significantly different averages between CVSM and RVSM [$F(1, 8) = 6.74$]. Both T/O average ratings were above 6.01, therefore, the significance was considered not practical. Controller self-ratings indicated no significant difference between CVSM and RVSM for Scenario 1. Both controller and T/O measures failed to indicate any practical impact on the controller's ability to accurately input control commands due to RVSM for Scenario 1.

3.2.10 SAR Variables

Analysis of various SAR variables showed no significant difference between CVSM and RVSM for ACCPT, AM, ERROR, QF QP, QQ, QR, QX, REJECT, or SR messages for all scenarios. Refer to Table 5 for a complete list of SAR acronyms and their meanings.

Analysis of SAR recordings for Scenario 1 showed a significant difference between CVSM and RVSM for the number of QN messages [$F(1, 17) = 5.37$]. The average number of QN messages was lower during RVSM than CVSM. A significant separation by position effect was found for QZ messages [$F(1, 17) = 4.27$]. An analysis by position showed that only the R control position had a significant difference [$F(1, 8) = 9.01$]. The average number of QZ messages for the R controller was greater for RVSM than CVSM.

The number of QZ messages was significantly different between CVSM and RVSM for Scenario 2 [$F(1, 9) = 7.15$]. The average number of messages was greater during RVSM than CVSM.

Analysis of SAR recordings for Scenario 4 showed a significant difference between CVSM and RVSM for QT messages [$F(1, 4) = 7.84$], QU messages [$F(1, 5) = 7.50$], and QZ messages [$F(1, 4) = 12.60$]. The average number of messages was greater during RVSM than CVSM for all three message types.

3.3 RVSM vs. RVSM-E

Scenario 3 did not have any runs with contingency operations, therefore, it is not included in this section.

3.3.1 Maintaining Separation

Analysis of controller self-ratings for maintaining separation showed a significant difference between RVSM and RVSM-E for Scenario 1 [$F(1, 8) = 28.80$]. The average rating was lower for RVSM-E than RVSM. T/O ratings had a significant sector by separation interaction for Scenario 1 [$F(1, 8) = 6.88$]. An analysis by sector revealed a significant separation effect for R60 [$F(1, 4) = 7.60$]. The average rating for RVSM-E was less than the average for RVSM.

Analysis of self-rated values for maintaining separation showed a significant difference between RVSM and RVSM-E for Scenario 2 [$F(1, 4) = 25.00$]. Both controller average ratings were above 6.01, therefore, the significance was considered not practical. An analysis of T/O ratings also showed a significant difference between RVSM and RVSM-E for Scenario 2 [$F(1, 4) = 7.70$]. The average for RVSM-E was lower than the average for RVSM.

Analysis of self-rated values for separation showed a significant difference between RVSM-E and RVSM for Scenario 4 [$F(1, 7) = 9.39$]. An analysis of T/O ratings showed the same [$F(1, 7) = 9.58$]. For Scenario 4, the average ratings for separation were lower during RVSM-E than RVSM for both controllers and T/Os.

3.3.2 Workload

The following section discusses interval and post-run workload ratings. The average T/O and controller workload ratings were higher for RVSM-E than RVSM. All average ratings follow the same trend regardless of their statistical significance or who gave the rating.

The self-rated interval workload was significantly different between RVSM and RVSM-E for Scenario 1 [($F(1, 43) = 8.23$]. An analysis of T/O interval ratings showed the same [$F(1, 43) = 9.52$]. During Scenario 1, the average interval workload was higher for RVSM-E than RVSM for both controllers and T/Os.

An analysis of Scenario 1 post-run workload further supported the workload difference between RVSM and RVSM-E. The self-rated post-run workload was significantly different between RVSM and RVSM-E [$F(1, 8) = 10.26$]. An analysis of T/O post-run workload showed the same [$F(1, 8) = 43.68$]. During Scenario 1, the average post-run workload was higher for RVSM-E than RVSM for both controllers and T/Os.

Analysis of self- and T/O-rated values for interval and post-run workload resulted in no significant difference between RVSM and RVSM-E for Scenario 2. The controller and T/O ratings failed to indicate any impact on workload for Scenario 2 due to contingency operations.

A significant difference between RVSM and RVSM-E was found for T/O rated interval workload for Scenario 4 [$F(1, 44) = 19.94$]. The average interval workload was higher for RVSM-E than RVSM. This was not confirmed by self-ratings, which resulted in no significant difference between CVSM and RVSM for Scenario 4.

An analysis of T/O post-run workload further supported the workload difference between RVSM and RVSM-E for Scenario 4. The T/O-rated post-run workload was significantly different between RVSM and RVSM-E [$F(1, 9) = 13.02$]. No separation effect was found for controller ratings. During Scenario 4, the average post-run workload was higher for RVSM-E than RVSM for both controllers and T/Os.

3.3.3 Frequency of Communications

Analysis of the number of recorded communications revealed a significant difference in the number of communications between RVSM and RVSM-E for Scenario 1 [$F(1, 8) = 64.83$] and Scenario 2 [$F(1, 4) = 6.63$]. For both scenarios, the average frequency of communications was higher for RVSM-E than RVSM.

Scenario 4 had a significant separation by position interaction [$F(2, 9) = 10.05$]. The R position experienced a 22% increase in the average number of communications under RVSM-E compared to RVSM. The A position average more than doubled. However, the D position experienced a 27% decrease in the average number of communications during RVSM-E compared to RVSM.

3.3.4 Communication Rating

No significant difference between RVSM and RVSM-E was found for Scenarios 2 and 4 for both self- and T/O-ratings. These results failed to indicate any impact on the controller's ability to follow ATP communication specifications due to contingency operations.

An analysis of self-ratings for communication showed that Scenario 1 had a significantly different average rating for RVSM than RVSM-E [$F(1, 8) = 24.00$]. The average rating for RVSM was higher than the average for RVSM-E. This was confirmed by Scenario 1 T/O ratings, which also had significantly different ratings [$F(1, 11) = 12.75$]. The average T/O rating given during RVSM was also higher than the average for RVSM-E. However, all average ratings were above 6.01, therefore, the significance found for the controller and T/O ratings was considered not practical.

3.3.5 Coordination Rating

Analysis of self-ratings for coordination showed that Scenario 1 had a significant difference between RVSM and RVSM-E [$F(1, 8) = 5.35$]. The average rating for RVSM was higher than the average for RVSM-E. An analysis of T/O ratings confirmed that Scenario 1 had significantly different ratings [$F(1, 8) = 17.29$]. Both of these average ratings were above 6.01, therefore, the significance of the T/O ratings was considered not practical.

Analysis of self-ratings for coordination showed that Scenario 2 had a significantly different average value for RVSM than RVSM-E [$F(1, 4) = 9.00$]. Both controller average ratings were above 6.01, therefore, the significance was considered not practical. T/O ratings indicated no significant difference between RVSM and RVSM-E for Scenario 2. Both controller and T/O measures failed to indicate any practical impact on controller coordination for Scenario 2 due to contingency operations.

Scenario 4 resulted in no significant difference between RVSM and RVSM-E for both T/O- and self-ratings. The controller and T/O ratings failed to indicate any impact on controller coordination for Scenario 4 due to contingency operations.

3.3.6 Situational Awareness

No significant difference between RVSM and RVSM-E was found for Scenarios 2 and 4 for both self- and T/O-ratings. These results failed to indicate any impact on the controller's situational awareness due to contingency operations. Although not significant, the averages for RVSM-E were lower than RVSM.

The self-rated values for situational awareness were significantly different between RVSM-E and RVSM for Scenario 1 [$F(1, 8) = 60.75$]. The average rating was lower for RVSM-E than RVSM. This was confirmed by T/O ratings only for sector R60. T/O ratings had a significant separation by sector interaction [$F(1, 8) = 7.84$]. An analysis by sector showed that sector R60 had a significant difference between RVSM-E and RVSM [$F(1, 4) = 15.43$]. The average T/O situational awareness rating for sector R60 was lower during RVSM-E than RVSM.

3.3.7 Priority of Actions

Analysis of self-rated values for priority of actions showed a significant difference between RVSM and RVSM-E for Scenario 1 [$F(1, 8) = 8.07$]. T/O ratings also showed a significant difference [$F(1, 8) = 12.00$]. The average rating for priority of actions was lower during RVSM-E than RVSM for both controllers and T/Os. All average ratings were above 6.01, therefore, the significance found for the controller and T/O ratings was considered not practical.

T/O ratings for Scenario 2 showed a significant difference between RVSM and RVSM-E [$F(1, 4) = 6.58$]. Both T/O average ratings were above 6.01, therefore, the significance was considered not practical. Controller self-ratings indicated no significant difference between RVSM and RVSM-E for Scenario 2. Both controller and T/O measures failed to indicate any practical impact on the controller's priority of actions for Scenario 2 due to contingency operations.

T/O ratings also showed a significant difference for Scenario 4 [$F(1, 8) = 5.70$]. The average rating for RVSM-E was lower than RVSM. Although the difference was not statistically different, self-rated averages were also lower for RVSM-E than RVSM for Scenario 4.

3.3.8 Flight Strips

No significant difference was found for Scenarios 2 and 4 for both self- and T/O-ratings. These results failed to indicate any impact on the controller's ability to manage flight strips due to contingency operations. Although not significant, the averages for RVSM-E were lower than RVSM.

Scenario 1 self-rated values for flight strips were significantly different between RVSM-E and RVSM [$F(1, 8) = 7.04$]. The average self-rating was lower for RVSM-E than RVSM. T/O ratings showed a significant sector by separation interaction for Scenario 1 [$F(1, 8) = 9.63$]. An analysis by sector showed that only sector R60 had a significant separation effect [$F(1, 8) = 8.79$]. The average T/O rating for sector R60 was lower for RVSM-E than RVSM.

3.3.9 Computer Entry

Self-reported ratings for computer entry were significantly different between RVSM and RVSM-E for Scenario 1 [$F(1, 9) = 5.14$]. The average self-rating was lower for RVSM-E than RVSM [$F(1, 8) = 9.00$]. An analysis by sector showed that sector R60 had a significant separation effect. However, all average ratings were above 6.01, therefore, the significance found for the controller and T/O ratings was considered not practical.

Scenario 2 average self-ratings for computer entry had a significant separation by position interaction [$F(1, 4) = 9.00$]. The average value was lower for the R position during RVSM-E as compared to RVSM. Both controller average ratings were above 6.01, therefore, the significance was considered not practical. T/O ratings indicated no significant difference between RVSM and RVSM-E for Scenario 2. Both T/O and controller measures failed to indicate any practical impact on the controller's ability to accurately input control commands for Scenario 2 due to contingency operations.

Scenario 4 controller ratings revealed a significant separation by position interaction [$F(2, 7) = 7.83$]. An analysis by position showed that the R position had a significant separation effect [$F(1, 3) = 49.00$]. The average R position rating was lower for RVSM-E than RVSM. T/O ratings for Scenario 4 also revealed a significant separation by position interaction [$F(1, 8) = 8.91$]. An analysis of T/O ratings by position also showed that the R position had a separation effect [$F(1, 3) = 16.33$]. The average T/O rating for the R position was also lower for RVSM-E than RVSM.

3.3.10 SAR Variables

Analysis of SAR variables resulted in no significant difference between RVSM and RVSM-E for ACCPT, AM, ERROR, QF, QN, QP, QQ, QR, QU, QZ, or SR messages. Scenario 2 is not analyzed here because not enough runs were recorded. Refer to Table 5 for a complete list of SAR acronyms and their meanings.

Analysis of QT messages showed that Scenario 1 had a significant separation by position interaction [$F(1, 9) = 30.07$]. When values were analyzed separately by position, the R controller showed a significant separation effect [$F(1, 4) = 36.75$]. The average number of recorded messages decreased for the R controller from RVSM to RVSM-E.

Analysis of QT messages showed that Scenario 4 had a significant separation by position interaction [$F(1, 4) = 9.15$]. The average number of QT messages decreased for the R controller from RVSM to RVSM-E. Analysis of QX messages showed a significant difference between RVSM-E and RVSM [$F(1, 5) = 7.50$]. During Scenario 4, the average number of QX messages was lower for RVSM-E than RVSM.

3.4 Safety Issues

There were 173 answers to question 4 of the Post-Run Questionnaire, "What was your primary safety concern during the last simulation run?" Of the 173 answers, 30 answers were not analyzed as safety concerns directly related to the procedure. Of the 30 discounted answers, 12 described experimental parameters as a concern (i.e., controllers did not fully understand the RVSM rules), 13 answers indicated the fidelity of the simulation (i.e., inefficient strip printing during start up), and 5 answers merely stated that the participant had no safety concerns. Of the remaining 143 answers, 150 distinct responses were identified.

The safety concerns were categorized into five main groups: Separation, Coordination, Data Blocks, Transitioning, and Other. Since the data were categorical, statistical chi-square analyses were completed where appropriate. Figure 14 characterizes the overall proportion of each type of safety concern by separation condition. As shown in the figure, the primary safety concern was maintaining separation regardless of the separation minima. During contingency operations, maintaining separation took even higher priority.

A chi-square analysis did not result in significant differences between CVSM and RVSM safety concerns. Transitioning was not a concern during CVSM runs because it is logically not applicable. RVSM-E was examined separately because safety concerns were logically expected to be substantially different during radar outages and severe weather. Area 2 and Area 4 safety concerns were also tested for differences because of the differences between the Areas. However, their differences were non-significant.

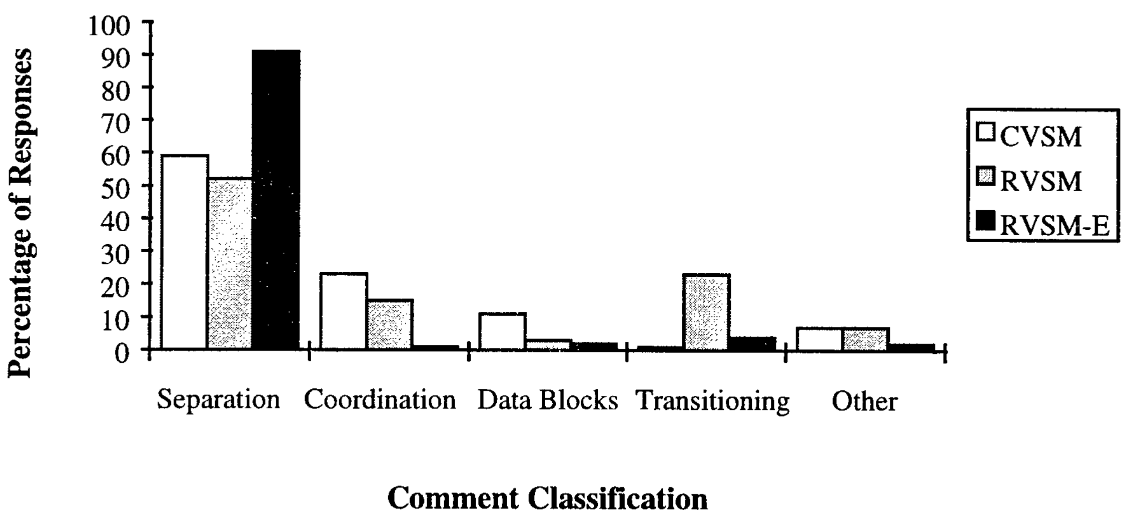

Figure 14. Safety concerns.

3.5 Changes in Control Strategies, Procedures, and Equipment

Questions 5 and 6 of the Post-Run Questionnaire (refer to Appendix B) inquired about changes in control strategies, procedures, or equipment due to RVSM. Fifty-five T/O responses and 104 controller responses were given for both. For question 5, 26% of the 104 controller responses were, "yes," they did change their usual control strategies. A higher percentage of T/Os' responses, 38%, answered, "yes," the controllers changed their usual control strategies. The response to question 6 was similar to question 5. Twenty-two percent of the controller responses were, "yes" they felt some equipment would have to be changed or new procedures implemented while 36% of the T/O responses were "yes."

For both questions, the changes included giving more attention to altitude assignments and becoming more aware of boundaries and non-radar traffic. Of those that responded "no," most indicated that further exposure to RVSM would increase their comfort level and that no additional procedures or equipment would be necessary.

4. Discussion

When interpreting and discussing results, the reader should consider that sectors R1, R60, and R63 were used as RVSM transition sectors. This was not a study of full RVSM implementation in the WATRS Area. Findings for a particular sector during this study may not necessarily be the same if full implementation was studied. Additional studies may need to be conducted to understand the impact of full RVSM implementation within the WATRS Area.

4.1 CVSM vs. RVSM

Results from Scenarios 1, 2, and 3 did not indicate a clear difference between CVSM and RVSM for sectors R60 and R63 or the combined sectors R62/63 or R60/62/63. There was not a significant difference between CVSM and RVSM for most subjective or objective measures. The recorded number of operational errors did not increase under RVSM for Scenarios 1 and 2 and sector R60/62/63 of Scenario 3. The recorded number of QZ (assigned altitude, etc.) messages increased for Scenarios 1 (R position only) and 2 during RVSM conditions. Controllers confirmed that this was due to assigning more altitudes during RVSM. There were significantly less QN (data block offset, force data block, etc.) messages under RVSM than CVSM for Scenario 1. The lower average for RVSM was thought to be the result of performing data block offset and force data block. Because these two functions are more cosmetic than necessary in nature, it would follow that controllers would be less likely to perform these actions when they have other higher priority actions to perform. Controllers also mentioned that the data blocks were almost overlapping in some cases. However, they did not feel RVSM increased data block overlap problems.

Scenario 4 post-run and interval workload ratings indicated that RVSM was significantly more workload intensive that CVSM for sector R62/63. Also, a greater number of operational errors and deviations were recorded during RVSM than CVSM for Scenario 4. Some of the errors were RVSM violations. This seems to indicate that RVSM transitions have a greater effect on the controller when they are working with a higher number of aircraft, which was the case in Scenario 4. In addition, a greater number of QT, QU, and QZ messages were recorded during RVSM.

As previously mentioned, sector R1 was the only sector from Area 2. It had different rules for RVSM transition and a lot more crossing traffic than the other sectors from Area 4. Examination of all the results clearly indicate that for sector R1, studied during Scenario 3, the controllers incurred a greater hardship when controlling traffic with RVSM than with CVSM. R1 had lower ratings during RVSM for the ability to maintain separation, communication, and situational awareness. The post-run workload was higher during RVSM than CVSM. In support of the subjective measures, operational errors and deviations relating to separation were observed for sector R1 during RVSM, but no operational errors or deviations were observed during CVSM.

4.2 RVSM vs. RVSM-E

During contingency operations, all scenarios showed an increase in the frequency of communications. This was expected because a contingency event usually requires additional communication between the controller and pilot. However, there was no indication that this increase resulted in a decreased ability to follow communication specifications. In the case of three controllers, it appears that the A controller may become more active in communications during the contingency operation thus decreasing the number of communications made by the D controller and allowing that controller to focus on other activities.

Controllers and T/Os agreed that RVSM-E was more workload intensive than RVSM for Scenario 1. Controllers also felt that they had more difficulties with coordination, situational awareness, flight strip management, and maintaining separation during RVSM-E. T/Os reported similar results for sector R60. This finding was supported by three recorded operational errors and deviations for sector R60 during RVSM-E, which were related to maintaining separation and flight strip management. Also, it was found that regardless of the sector, the R controller entered significantly less QT (assigned altitude, coast track, track) messages during the RVSM-E condition. This is most likely due to the controller becoming more focused on the contingency events and, therefore, not assigning as many altitudes.

T/Os felt that controllers had a greater difficulty maintaining separation during RVSM-E compared to RVSM for Scenario 2, particularly for sector R60. This is supported by two operational errors related to separation made in sector R60 during RVSM-E. Neither the controllers nor the T/Os felt that most of the other controller capabilities were affected by contingency operations during this scenario (i.e., workload, situational awareness, and priority of actions).

T/Os found RVSM-E more workload intensive than RVSM for Scenario 4. Controller post-run ratings indicated the same. The ability to maintain separation and priority of actions were also degraded during RVSM-E. This is supported by the numerous operational errors and deviations recorded relating to separation and a failure to perform an action. There was also indication that the contingency operations affected the R controllers computer entry abilities. The R position had significantly less QT messages during RVSM-E conditions. Therefore, during contingency operations, the R controller could not assign as many altitudes. QX (drop tracks only) messages were also less frequent during RVSM-E. This may be because the controllers wanted to keep an accurate picture of all the aircraft during contingency operations or they were too busy with higher priority actions.

4.3 Conflict Alert

The participants discussed whether it is better to have the Conflict Alert activate too many times rather than going off too few times. They suggested that the RVSM-equipped aircraft be identified by a special mark. Therefore, Conflict Alert for these aircraft could be neglected if the alert threshold is set for 2000 ft. They also indicated that it might be possible to use the suppressed group for RVSM-equipped aircraft; thus, the Conflict Alert would not be activated at 1000-ft altitude differential. If the suppressed group arrangement would not be possible, it is preferred that the Conflict Alert threshold be set at 2000 ft.

4.4 Impact of Bad Weather With RVSM

During debrief sessions, participants indicated that the location of adverse weather would determine the impact on the controllers ability to control traffic during RVSM. They mentioned that if the bad weather were closer to the transition boundary with RVSM, it would considerably increase their workload. However, if the adverse weather were not close to the transition boundary, they would get more altitudes and, therefore, have more flexibility to arrange all aircraft around the bad weather.

4.5 Increased Traffic Under RVSM Separation

One consideration of RVSM implementation is whether more aircraft can be managed with RVSM as compared to CVSM. To address this issue, this section discusses workload and operational errors/deviations for sector R62/63. Data from Scenarios 2 and 4 were selected because they both used sector R62/63 and had a different number of aircraft. Scenario 2, was run with 27 aircraft and two controllers and Scenario 4 had 39 aircraft and three controllers.

An examination of data for CVSM with 27 aircraft and CVSM with 39 aircraft showed that the increase in traffic did not result in an increase in workload. However, RVSM with 27 aircraft compared to RVSM with 39 aircraft showed that workload and operational errors/deviations increased with more traffic. Finally, an inspection of CVSM with 27 aircraft and RVSM with 39 indicated that workload and operational errors/deviations increased during RVSM. This data indicates that using these sectors for RVSM transitions does not necessarily allow an increased traffic flow while maintaining current workload levels.

5. Conclusion

Trends in the data indicate that controlling traffic in the studied sectors would be easier under the current separation compared to using them as RVSM transition sectors. The Area 4 controllers' ability does not appear to be affected by RVSM when traffic levels are lower. With higher levels of traffic, however, the controllers experienced higher workload and had more operational errors during RVSM compared to CVSM. Errors specifically related to RVSM, such as not transitioning by the boundary, occur at higher traffic levels. Regardless of the traffic level, it seems that with RVSM the Area 4 controllers assigned more altitudes than with CVSM. The effect of RVSM on the Area 2 controller was clearer. Tests were only done at a lower traffic level and results show that Area 2 controllers had greater difficulty controlling traffic during RVSM than CVSM.

For Area 4, contingency operations affected important controller functions such as the ability to maintain separation and usually increased workload. This resulted in an increased number of operational errors. Guidelines to handle potential complications such as radar outages and bad weather need to be developed before RVSM can be safely implemented.

Overall, the introduction of RVSM in sectors R1, R60, R63, R62/63, R60/62/63 did not appear to impact the controllers' safety priorities or controlling strategies. They still felt that maintaining separation was their primary safety concern. Transition was discussed during RVSM runs in addition to their current concerns. Some participants indicated that they made minimal changes to their controlling strategy to accommodate RVSM transitions. These included giving more attention to altitude assignments and becoming more aware of boundaries and non-radar traffic.

Participants pointed out that non-RVSM participating aircraft might create a problem for controllers because they will have to enforce the 2000-ft separation minima, particularly at crossing fixes. Non-participating aircraft may be penalized severely and forced to use an altitude that is not assigned for RVSM.

Some participants felt that a few changes needed to be made for RVSM implementation; require all aircraft operating in this space to be RVSM equipped, increase the transition airspace, and have access to more reliable radar. However, a majority of participants indicated that experience would make them more comfortable with RVSM and that no changes would be necessary.

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Acronyms

7110.65	FAA Air Traffic Controllers Handbook
A	Assistant Controller
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATS	Air Traffic Service
D	Data Controller
CRD	Computer Readout Display
CVSM	Conventional Vertical Separation Minima
DART	Data Analysis and Reduction Tool
DYSIM	Dynamic Simulation
EWG	Experimentation Working Group
FAA	Federal Aviation Administration
FL	Flight level
FPL	Full Performance Level
FT	Feet, foot
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
MASPS	Minimum Aircraft System Performance Specification
MNPS	Minimum Navigation Performance Specification
NAT	North Atlantic
NATSPG	North Atlantic System Planning Group
NSC	National Simulation Capability
PVD	Plan View Display
R	Radar
RGCSP	Review of the General Concept of Separation Panel
RVSM	Reduced Vertical Separation Minima
SAR	System Analysis and Recording
SIM	Simulated
TLS	Target Level of Safety
T/O	Technical Observer
WATRS	Western Atlantic Track Route System
VSM	Vertical Separation Minimum
ZMA	Miami ARTCC
ZNY	New York ARTCC

Appendix A

Individual Sector Maps

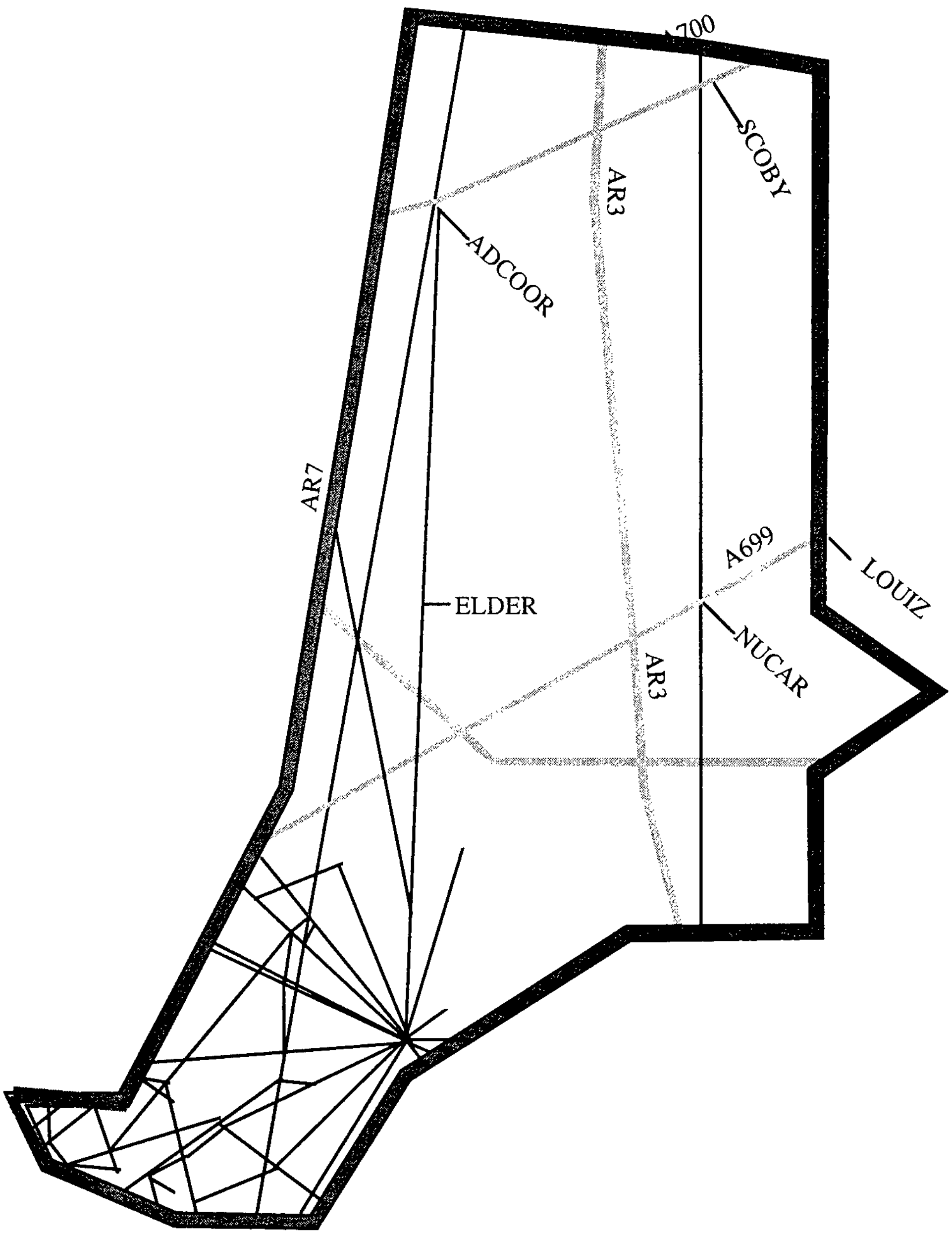

Figure A1. Individual sector map for R1.

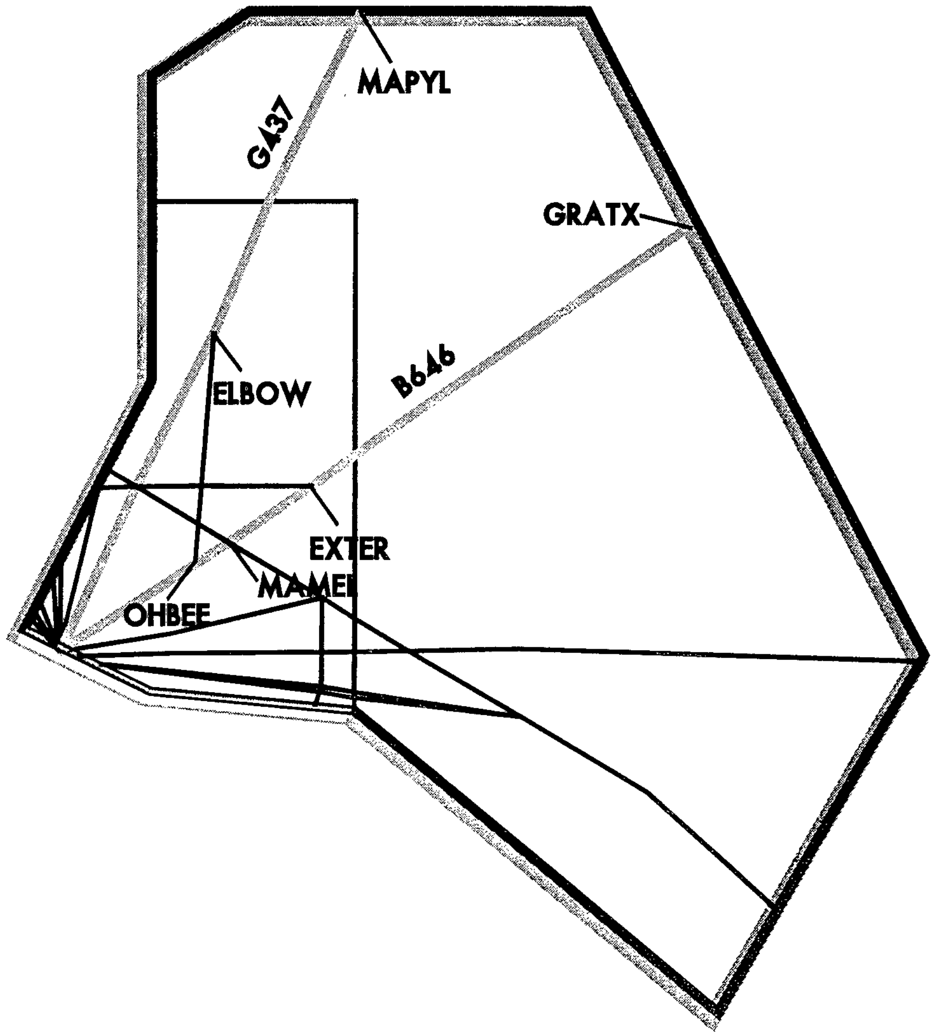

Figure A2. Individual sector map for R60.

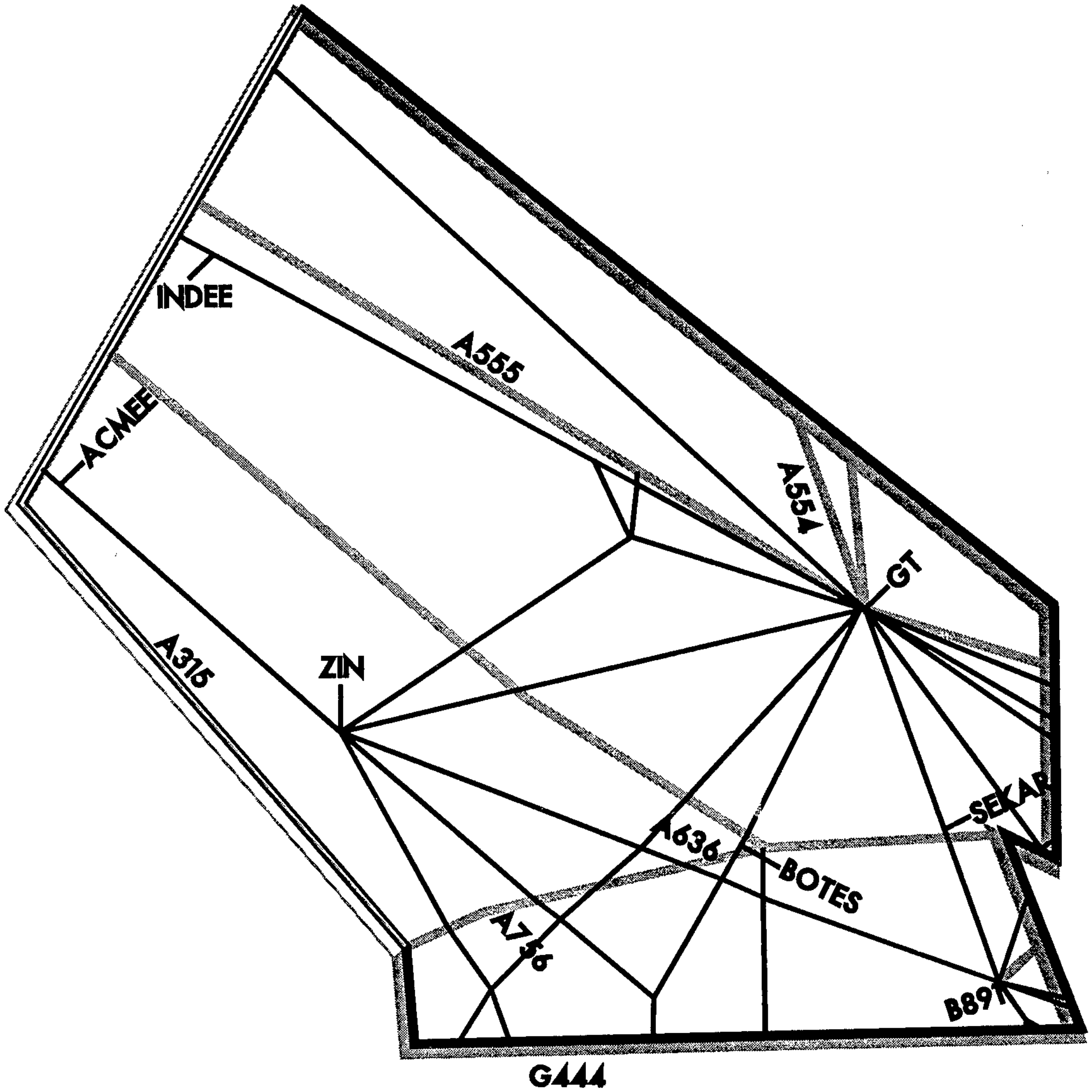

Figure A3. Individual sector map for R62.

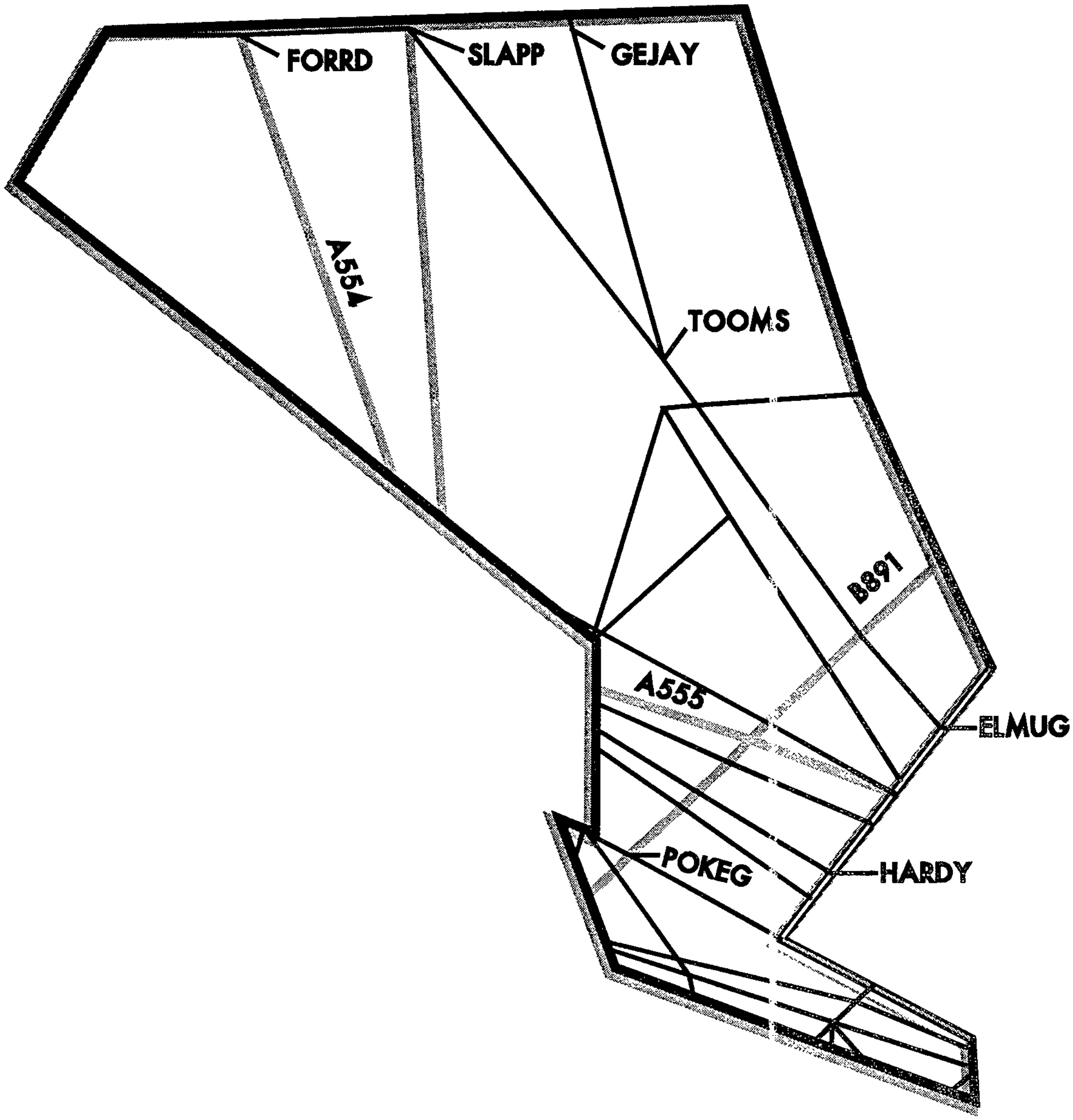

Figure A4. Individual sector map for R63.

APPENDIX B

Background Information Form and Post-Run Questionnaire

BACKGROUND INFORMATION FORM
INSTRUCTION SHEET:

This form is to be completed by all RVSM Phase III participants. The form requests general background information and judgments regarding oceanic control practices.

Your name will not be listed or appear in any reports in order to insure your anonymity and to encourage unbiased reporting. Findings will be reported generically, ex. Controller A, B, C, etc.

When making your ratings, please consider all levels of the scale. You are encouraged to mark down any additional comments you feel are important.

BACKGROUND INFORMATION FORM

Controller ❐ Observer ❐ ID#: ____________

Date: ____________ Age: _____

1. How long have you actively controlled traffic for the FAA?
   Years: _______ Months: _______

2. How many of the past 12 months have you actively controlled traffic in this facility?
   Months: _______

3. Are you an FPL?
   Yes ❐ No ❐
   3A. If yes, how long and for what area?
   Years: _______ Months: _______ Area: __________

   3B. If no, which sectors are you checked out on?
   1. ______ 2. ______ 3. _______ 4. ______ 5 ______ 6. ______

4. Name the last 3 facilities (FAA) you have worked at starting with your current assignment?
   1.__________________ 2.__________________ 3.__________________

5. Have you had experience training controllers for the FAA?
   Yes ❐ No ❐

6. Based on your experience with high traffic/workload in the domestic oceanic or WATRS area:

6A. What are some of the things that can occur that could cause you to have significant difficulties in maintaining a safe and expeditious traffic flow?

____
____
____
____
____
____

6B. Which of these events tend to occur most frequently?

____
____
____
____
____
____

BACKGROUND INFORMATION FORM (cont.)

7. Please rate the following for their contribution to high workload levels in your current ATC environment. Circle your response using the scale shown below.

1 -	Very Low Contribution -	Rarely affects your ability to complete control tasks
8 -	Very High Contribution -	Frequently affects your ability to complete control tasks

A. Random Routing

1	2	3	4	5	6	7	8
Very Low Contribution							Very High Contribution

B. Mix of Aircraft Performance/Characteristics

1	2	3	4	5	6	7	8
Very Low Contribution							Very High Contribution

C. Coordination with Foreign Facilities

1	2	3	4	5	6	7	8
Very Low Contribution							Very High Contribution

D. Coordination with Fellow Controllers

1	2	3	4	5	6	7	8
Very Low Contribution							Very High Contribution

E. Flight Strip Printer Speed

1	2	3	4	5	6	7	8
Very Low Contribution							Very High Contribution

F. ARINC Communications

1	2	3	4	5	6	7	8
Very Low Contribution							Very High Contribution

G. Phone System

1	2	3	4	5	6	7	8
Very Low Contribution							Very High Contribution

H. Other. Please list and explain below.

EXPLAIN: ______________________________

____

____

____

CONTROLLER POST-RUN FORM
INSTRUCTION SHEET:

This form is to be completed by all Air Traffic Controllers participating in RVSM Phase III. The form requests information regarding your overall experiences and judgments about the run that you just completed.

Your name will not be listed or appear in any reports in order to insure your anonymity and to encourage unbiased reporting. Findings will be reported generically, ex. Controller A, B, C, etc.

When making your ratings, please consider all levels of the scale. You are encouraged to mark down any additional comments you feel are important.

CONTROLLER POST-RUN FORM

Date: ______________ ID#: ________________ Sector: __________

Scenario: ____________ Control Position: R ☐ D ☐ A ☐

1. What was your overall workload level during this problem? Circle your response using the scale shown below.

   1 - Easily completed all tasks accurately
   8 - Could not complete all tasks

1	2	3	4	5	6	7	8
Very Low							Very High

2. Rate your performance for the following factors according to the prescribed scales:

A. Coordination

Provided complete and correct information for clearances and estimates in a timely manner.

1 - Frequently gave incorrect or incomplete information
8 - Always gave correct information

1	2	3	4	5	6	7	8
Very Low							Very High

NOTES: ____________________

B. Maintenance of Situational Awareness

Addressed all aspects of airspace and aircraft.

1 - Could not maintain awareness
8 - Easily maintained awareness

1	2	3	4	5	6	7	8
Poor Awareness							Complete Awareness

NOTES: ____________________

C. Communication

Used ATP 7110.65 specifications.

1 - Rarely followed ATP 7110.65 specifications
8 - Always followed ATP 7110.65 specifications

1	2	3	4	5	6	7	8
Rarely							Always

NOTES: ____________________

D. Priority of Actions

Issued control instructions in prioritized, structured manner as specified in 7110.65.

1 - Did not follow specified priority
8 - Always followed specified priority

1	2	3	4	5	6	7	8
Very Low							Very High

NOTES: ____________________

CONTROLLER POST-RUN FORM (cont.)

E. Flight Strip Management

Marked strips accurately while performing other tasks; kept strips current.

1 - Could not maintain strips
8 - Easily maintained strips

1	2	3	4	5	6	7	8
Very Low							Very High

NOTES:

F. Maintenance of Separation

Adhered to separation standards as specified in 7110.65.

1 - Could not maintain separation
8 - Easily maintained separation

1	2	3	4	5	6	7	8
Very Low							Very High

NOTES:

G. Computer Entry

Accurately input control commands into key panel.

1 - Had great difficulty inputting commands
8 - Easily and accurately input commands

1	2	3	4	5	6	7	8
Many Errors							No Errors

NOTES:

---

3. Please rate the following simulation characteristics for realism compared to Miami's current operations? Please explain.

A. Traffic Flow (traffic patterns, traffic volume, etc.)

1	2	3	4	5	6	7	8
Very Unrealistic							Very Realistic

EXPLAIN:

CONTROLLER POST-RUN FORM (cont.)

B. Physical Environment (PVDs, lighting, etc.)

1	2	3	4	5	6	7	8
Very Unrealistic							Very Realistic

EXPLAIN:

C. Taskload (# communications, # requests, etc.)

1	2	3	4	5	6	7	8
Very Unrealistic							Very Realistic

EXPLAIN:

4. What was your primary safety concern during the last simulation run?

5. Did you change your usual control strategies in any way while working with RVSM traffic?
   Yes ☐ If yes, please explain. No ☐ Not an RVSM run ☐
   EXPLAIN:

6. Based upon your experience with RVSM in the last run, would any procedures or equipment have to be changed and/or implemented in order for you to feel comfortable about controlling RVSM traffic?
   Yes ☐ If yes, please explain. No ☐ Not an RVSM run ☐
   EXPLAIN:

OBSERVER FORM (R & D)
INSTRUCTION SHEET:

This form is to be completed by all Air Traffic Controllers participating in RVSM Phase III. The form requests information regarding your overall experiences and judgments about the run that you just completed.

Your name will not be listed or appear in any reports in order to insure your anonymity and to encourage unbiased reporting. Findings will be reported generically, ex. Observer A, B, C, etc.

When making your ratings, please consider all levels of the scale. You are encouraged to mark down any additional comments you feel are important.

OBSERVER FORM (R & D)

Date: ________ ID#: ________ Controller ID#: R ________ D ________
Scenario: ________ Start Time: ________ Sector: ________

When prompted, please rate controllers on your perception of their workload. In addition, note the time you were prompted.

1 - Easily completed all tasks accurately
8 - Could not complete all tasks

Interval 1 Time: ________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8

Interval 2 Time: ________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8

Interval 3 Time: ________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8

Interval 4 Time: ________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8

NOTES: ____

Time: ______ : ______ : ______
EXPLAIN: ____

Time: ______ : ______ : ______
EXPLAIN: ____

Time: ______ : ______ : ______
EXPLAIN: ____

Time: ______ : ______ : ______
EXPLAIN: ____

OBSERVER POST-RUN FORM (R & D cont.)

1. What did you perceive to be the controller's overall workload level during this problem?

1 -	Easily completed all tasks accurately								
8 -	Could not complete all tasks								
R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Very Low							Very High	

2. Rate the controller's performance during this problem on the following aspects:

A. Coordination

Provided complete and correct information for clearances and estimates in a timely manner.

1 - Frequently gave incorrect or incomplete information									
8 - Always gave correct information									
R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Very Low							Very High	

NOTES: ______________________________

____

____

B. Maintenance of Situational Awareness

Addressed all aspects of airspace and aircraft.

1 - Could not maintain awareness									
8 - Easily maintained awareness									
R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Poor Awareness							Complete Awareness	

NOTES: ______________________________

____

____

C. Communication

Used ATP 7110.65 specifications.

1 - Rarely followed ATP 7110.65 specifications									
8 - Always followed ATP 7110.65 specifications									
R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Rarely							Always	

NOTES: ______________________________

____

____

D. Priority of Actions

Issued control instructions in prioritized, structured manner as specified in 7110.65.

1 - Did not follow specified priority									
8 - Always followed specified priority									
R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Very Low							Very High	

NOTES: ______________________________

____

____

OBSERVER POST-RUN FORM (R & D cont.)

E. Flight Strip Management

Marked strips accurately while performing other tasks; kept strips current.

1 - Could not maintain strips
8 - Easily maintained strips

R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Very Low							Very High	

NOTES:

F. Maintenance of Separation

Adhered to separation standards as specified in 7110.65.

1 - Could not maintain separation
8 - Easily maintained separation

R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Very Low							Very High	

NOTES:

G. Computer Entry

Accurately input control commands into key panel.

1 - Had great difficulty inputting commands
8 - Easily and accurately input commands

R	1	2	3	4	5	6	7	8	N\A
D	1	2	3	4	5	6	7	8	N\A
	Many Errors							No Errors	

NOTES:

3. Please rate the following simulation characteristics for realism compared to Miami's current operations? Please explain.

A. Traffic Flow (traffic patterns, traffic volume, etc.)

1	2	3	4	5	6	7	8
Very Unrealistic							Very Realistic

EXPLAIN:

B. Physical Environment (PVDs, lighting, etc.)

1	2	3	4	5	6	7	8
Very Unrealistic							Very Realistic

EXPLAIN:

OBSERVER POST-RUN FORM (R & D cont.)

C. Taskload (# communications, # requests, etc.)

1	2	3	4	5	6	7	8
Very Unrealistic							Very Realistic

EXPLAIN: ______________________________

____

____

4. What was your primary safety concern during the last simulation run?

____

____

____

____

5. Did the controller change her/his control strategies used during CVSM in order to work with RVSM traffic?

Yes ❒ If yes, explain what she/he did. No ❒ Not an RVSM run ❒

EXPLAIN "R": ______________________________

____

____

____

____

____

EXPLAIN "D": ______________________________

____

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____

____

6. Based upon your experience with RVSM in the last run, would any procedures or equipment have to be changed and/or implemented in order for you to feel comfortable about controlling RVSM traffic?

Yes ❒ If yes, please explain. No ❒ Not an RVSM run ❒

EXPLAIN: ______________________________

____

____

____

____

____

SUPPORT TEAM FORM
INSTRUCTION SHEET:

1. This form is to be used by NSC support personnel.

2. Prompt controllers every 15 minutes to give their workload level. In addition, note the time the controller was asked to respond.

3. Note the number of communications by each controller with a hash mark.

SUPPORT TEAM FORM

Date: ____________ Controller ID#: R __________ D __________ A __________
Scenario: ________ Sector: _______

Controller Self Reported Workload Ratings.

Interval 1 Time: ____________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8
A	1	2	3	4	5	6	7	8

COMMUNICATIONS	
R	D

Interval 2 Time: ____________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8
A	1	2	3	4	5	6	7	8

COMMUNICATIONS	
R	D

Interval 3 Time: ____________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8
A	1	2	3	4	5	6	7	8

COMMUNICATIONS	
R	D

Interval 4 Time: ____________

R	1	2	3	4	5	6	7	8
D	1	2	3	4	5	6	7	8
A	1	2	3	4	5	6	7	8

COMMUNICATIONS	
R	D

Appendix C

Controller and Observer Background Summaries

Table C1. Controller Background Information Summary

	Frequency	Mean	Std. Dev.
Participants	38	-	-
Age (Years)	-	33.1	3.45
Years Active for FAA	-	6.62	3.14
Years as FPL Status	35	4.28	3.28
Non-FPL Status	3	-	-
Number of Last 12 Months Active	-	11.96	0.36
Have Training Experience	16	-	-
No Training Experience	22	-	-
Work in Area 2	10	-	-
Work in Area 4	28	-	-
Worked Facilities Other Than ZMA	8	-	-

Table C2. Observer Background Information Summary

	Frequency	Mean	Std. Dev.
Participants	18	-	-
Age (Years)	-	33.3	3.8
Years Active for FAA	-	8.55	3.8
Years as FPL Status	18	6.07	3.01
Non-FPL Status	0	-	-
Number of Last 12 Months Active	-	12	0
Have Training Experience	15	-	-
No Training Experience	3	-	-
Work in Area 2	5	-	-
Work in Area 4	13	-	-
Worked Facilities Other Than ZMA	3	-	-

Table C3. Controller and Observer Ratings for Effect of ATC Factors on Workload in Current ATC Environment

ATC Factor [a]	Area 2		Area 4	
	Mean	Std. Dev.	Mean	Std. Dev.
Random Routing	2.87	2.29	2.85	1.68
Mix of Aircraft Performance/Characteristics	4.40	2.03	4.32	1.79
Coordination with Foreign Facilities	2.07	1.58	5.90	1.50
Coordination with Fellow Controllers	3.27	1.62	2.83	1.41
Flight Strip Printer Speed	2.13	1.64	3.02	1.84
ARINC Communications	2.13	0.99	2.22	1.21
Phone System	3.20	1.52	4.44	2.32

[a] Ratings made on a scale from 1 to 8

Appendix D

Statistical Values of Measures

SCENARIO 1
Controller Post-Run Data

			Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
Sector	R63	C_AWARE	7.60	0.55	7.40	0.89	7.50	0.71
		R_AWARE	7.00	1.00	7.00	1.00	7.00	0.94
		E_AWARE	4.33	1.53	5.00	0.00	4.67	1.03
		C_COMM	7.60	0.55	7.80	0.45	7.70	0.48
		R_COMM	7.40	0.55	7.80	0.45	7.60	0.52
		E_COMM	6.00	1.00	6.33	0.58	6.17	0.75
		C_COMPUT	6.80	1.10	7.60	0.55	7.20	0.92
		R_COMPUT	7.00	1.00	7.40	0.55	7.20	0.79
		E_COMPUT	6.00	1.00	7.00	0.00	6.50	0.84
		C_COMTOT	111.80	23.79	75.20	13.81	93.50	26.62
		R_COMTOT	111.60	23.69	75.60	16.95	92.10	28.28
		E_COMTOT	138.67	22.12	119.00	26.96	128.83	24.55
		C_COORD	7.80	0.45	7.20	0.84	7.50	0.71
		R_COORD	7.20	0.84	7.40	0.89	7.30	0.82
		E_COORD	5.67	1.53	6.33	0.58	6.00	1.10
		C_PRIOR	7.80	0.45	7.40	0.89	7.60	0.70
		R_PRIOR	6.50	1.00	7.60	0.55	7.11	0.93
		E_PRIOR	5.67	0.58	6.33	0.58	6.00	0.63
		C_SEPAR	7.40	0.89	7.80	0.45	7.60	0.70
		R_SEPAR	7.00	1.00	7.80	0.45	7.40	0.84
		E_SEPAR	5.33	2.08	6.00	0.00	5.67	1.37
		C_STRIPS	7.20	0.84	7.40	0.55	7.30	0.67
		R_STRIPS	6.20	1.10	7.20	0.45	6.70	0.95
		E_STRIPS	3.67	2.08	6.33	0.58	5.00	2.00
		C_WORK	2.80	1.30	2.60	1.14	2.70	1.16
		R_WORK	3.60	2.07	3.80	1.64	3.70	1.77
		E_WORK	5.67	1.15	5.33	2.08	5.50	1.52
	R60	C_AWARE	7.60	0.55	8.00	0.00	7.80	0.42
		R_AWARE	7.60	0.55	7.60	0.55	7.60	0.52
		E_AWARE	4.33	1.53	5.00	1.00	4.67	1.21
		C_COMM	7.60	0.55	7.80	0.45	7.70	0.48
		R_COMM	7.40	0.55	7.60	0.55	7.50	0.53
		E_COMM	5.33	1.53	7.33	0.58	6.33	1.51
		C_COMPUT	7.80	0.45	7.80	0.45	7.80	0.42
		R_COMPUT	7.40	0.55	8.00	0.00	7.70	0.48

		E_COMPUT	7.00	1.00	7.33	0.58	7.17	0.75
		C_COMTOT	96.00	14.27	31.20	13.74	63.60	36.62
		R_COMTOT	97.80	19.28	36.20	17.40	67.00	36.79
		E_COMTOT	134.67	16.35	93.67	6.66	101.50	37.49
		C_COORDS	7.60	0.55	6.80	2.68	7.20	1.87
		R_COORDS	7.60	0.55	7.40	0.89	7.50	0.71
		E_COORDS	4.67	3.51	6.33	1.53	5.50	2.59
		C_PRIOR	7.60	0.55	7.80	0.45	7.70	0.48
		R_PRIOR	7.40	0.55	7.80	0.45	7.60	0.52
		E_PRIOR	6.67	1.15	6.33	1.53	6.50	1.22
		C_SEPAR	8.00	0.00	8.00	0.00	8.00	0.00
		R_SEPAR	7.40	0.89	8.00	0.00	7.70	0.67
		E_SEPAR	4.00	2.00	6.00	1.00	5.00	1.79
		C_STRIPS	7.60	0.55	7.80	0.45	7.70	0.48
		R_STRIPS	5.40	2.61	7.60	0.55	6.50	2.12
		E_STRIPS	3.33	2.31	6.33	1.53	4.83	2.40
		C_WORK	1.20	0.45	1.40	0.55	1.30	0.48
		R_WORK	2.00	1.22	2.20	1.10	2.10	1.10
		E_WORK	5.00	1.73	5.67	0.58	5.33	1.21
Group Total		C_AWARE	7.60	0.52	7.70	0.67	7.65	0.59
		R_AWARE	7.30	0.82	7.30	0.82	7.30	0.80
		E_AWARE	4.33	1.37	5.00	0.63	4.67	1.07
		C_COMM	7.60	0.52	7.80	0.42	7.70	0.47
		R_COMM	7.40	0.52	7.70	0.48	7.55	0.51
		E_COMM	5.67	1.21	6.83	0.75	6.25	1.14
		C_COMPUT	7.30	0.95	7.70	0.48	7.50	0.76
		R_COMPUT	7.20	0.79	7.70	0.48	7.45	0.69
		E_COMPUT	6.50	1.05	7.17	0.41	6.83	0.83
		C_COMTOT	103.90	20.28	53.20	26.58	78.55	34.73
		R_COMTOT	104.70	21.62	54.40	25.11	79.55	34.44
		E_COMTOT	136.67	93.67	32.87	32.84	115.17	33.41
		C_COORD	7.70	0.48	7.00	1.89	7.35	1.39
		R_COORD	7.40	0.70	7.40	0.84	7.40	0.75
		E_COORD	5.17	2.48	6.33	1.03	5.75	1.91
		C_PRIOR	7.70	0.48	7.60	0.70	7.65	0.59
		R_PRIOR	7.00	0.87	7.70	0.48	7.37	0.76
		E_PRIOR	6.17	0.98	6.33	1.03	6.25	0.97
		C_SEPAR	7.70	0.67	7.90	0.32	7.80	0.52
		R_SEPAR	7.20	0.92	7.90	0.32	7.55	0.76

		E_SEPAR	4.67	1.97	6.00	0.63	5.33	1.56
		C_STRIPS	7.40	0.70	7.60	0.52	7.50	0.61
		R_STRIPS	5.80	1.93	7.40	0.52	6.60	1.60
		E_STRIPS	3.50	1.97	6.33	1.03	4.92	2.11
		C_WORK	2.00	1.25	2.00	1.05	2.00	1.12
		R_WORK	2.80	1.81	3.00	1.56	2.90	1.65
		E_WORK	5.33	1.37	5.50	1.38	5.42	1.31

SCENARIO 2
Controller Post-Run Data

			Position				**Group Test**	
			R		**D**		**Mean**	**Std. Dev.**
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**		
SECTOR	R60	C_AWARE	7.60	0.55	7.60	0.55	7.60	0.52
		R_AWARE	7.20	1.10	7.40	0.55	7.30	0.82
		E_AWARE	7.00	0.00	6.50	0.71	6.75	0.50
		C_COMM	7.80	0.45	7.60	0.55	7.70	0.48
		R_COMM	7.60	0.89	7.80	0.45	7.70	0.67
		E_COMM	7.50	0.71	7.50	0.71	7.50	0.58
		C_COMPUT	7.40	0.55	7.60	0.55	7.50	0.53
		R_COMPUT	7.20	1.10	7.60	0.55	7.40	0.84
		E_COMPUT	7.00	0.00	7.50	0.71	7.25	0.50
		C_COMTOT	114.20	13.63	58.20	32.95	86.20	37.90
		R_COMTOT	117.80	15.37	43.40	21.41	80.60	42.97
		E_COMTOT	136.00	31.11	78.00	52.33	107.00	48.55
		C_COORD	7.60	0.55	7.80	0.45	7.70	0.48
		R_COORD	7.60	0.55	7.40	0.55	7.50	0.53
		E_COORD	7.50	0.71	7.00	0.00	7.25	0.50
		C_PRIOR	7.80	0.45	7.80	0.45	7.80	0.42
		R_PRIOR	7.60	0.89	7.60	0.55	7.60	0.70
		E_PRIOR	6.50	0.71	7.00	0.00	6.75	0.50
		C_SEPAR	8.00	0.00	8.00	0.00	8.00	0.00
		R_SEPAR	8.00	0.00	8.00	0.00	8.00	0.00
		E_SEPAR	6.50	0.71	6.50	0.71	6.50	0.58
		C_STRIPS	7.00	1.22	7.40	0.89	7.20	1.03
		R_STRIPS	6.80	1.10	6.40	2.07	6.60	1.58
		E_STRIPS	6.00	0.00	7.00	0.00	6.50	0.58
		C_WORK	2.80	1.48	1.80	1.79	2.30	1.64
		R_WORK	2.60	1.14	2.00	1.22	2.30	1.16

		E_WORK	4.50	0.71	3.00	1.41	3.75	1.26
	R62/63	C_AWARE	7.40	0.55	6.60	1.14	7.00	0.94
		R_AWARE	7.00	1.41	6.60	1.34	6.80	1.32
		E_AWARE	6.50	0.71	7.00	1.41	6.75	0.96
		C_COMM	7.80	0.45	7.40	0.55	7.60	0.52
		R_COMM	7.80	0.45	7.40	0.89	7.60	0.70
		E_COMM	7.00	1.41	8.00	0.00	7.50	1.00
		C_COMPUT	7.60	0.55	7.80	0.45	7.70	0.48
		R_COMPUT	7.60	0.55	8.00	0.00	7.80	0.42
		E_COMPUT	7.00	0.00	8.00	0.00	7.50	0.58
		C_COMTOT	106.40	4.88	104.00	42.88	105.20	28.80
		R_COMTOT	109.80	17.60	126.80	28.95	118.30	24.30
		E_COMTOT	142.50	21.92	144.00	41.01	143.25	26.86
		C_COORD	7.60	0.55	7.40	0.55	7.50	0.53
		R_COORD	7.60	0.55	7.20	1.30	7.40	0.97
		E_COORD	6.00	0.00	7.50	0.71	6.75	0.96
		C_PRIOR	7.60	0.55	7.40	0.55	7.50	0.53
		R_PRIOR	7.40	0.55	7.60	0.89	7.50	0.71
		E_PRIOR	7.00	1.41	7.50	0.71	7.25	0.96
		C_SEPAR	7.80	0.45	7.80	0.45	7.80	0.42
		R_SEPAR	7.60	0.55	7.80	0.45	7.70	0.48
		E_SEPAR	6.50	0.71	7.50	0.71	7.00	0.82
		C_STRIPS	6.40	1.34	6.60	1.67	6.50	1.43
		R_STRIPS	7.00	0.71	6.00	1.41	6.50	1.18
		E_STRIPS	4.50	2.12	6.50	0.71	5.50	1.73
		C_WORK	3.20	1.10	4.20	2.39	3.70	1.83
		R_WORK	3.60	1.67	4.20	1.30	3.90	1.45
		E_WORK	5.00	1.41	4.00	0.00	4.50	1.00
Group Total		C_AWARE	7.50	0.53	7.10	0.99	7.30	0.80
		R_AWARE	7.10	1.20	7.00	1.05	7.05	1.10
		E_AWARE	6.75	0.50	6.75	0.96	6.75	0.71
		C_COMM	7.80	0.42	7.50	0.53	7.65	0.49
		R_COMM	7.70	0.67	7.60	0.70	7.65	0.67
		E_COMM	7.25	0.96	7.75	0.50	7.50	0.76
		C_COMPUT	7.50	0.53	7.70	0.48	7.60	0.50
		R_COMPUT	7.40	0.84	7.80	0.42	7.60	0.68
		E_COMPUT	7.00	0.00	7.75	0.50	7.38	0.52
		C_COMTOT	110.30	10.49	81.10	43.39	95.70	34.18
		R_COMTOT	113.80	16.14	85.10	50.08	99.45	39.09

	E_COMTOT	139.25	22.29	111.00	54.09	125.13	41.17
	C_COORD	7.60	0.52	7.60	0.52	7.60	0.50
	R_COORD	7.60	0.52	7.30	0.95	7.45	0.76
	E_COORD	6.75	0.96	7.25	0.50	7.00	0.76
	C_PRIOR	7.70	0.48	7.60	0.52	7.65	0.49
	R_PRIOR	7.50	0.71	7.60	0.70	7.55	0.69
	E_PRIOR	6.75	0.96	7.25	0.50	7.00	0.76
	C_SEPAR	7.90	0.32	7.90	0.32	7.90	0.31
	R_SEPAR	7.80	0.42	7.90	0.32	7.85	0.37
	E_SEPAR	6.50	0.58	7.00	0.82	6.75	0.71
	C_STRIPS	6.70	1.25	7.00	1.33	6.85	1.27
	R_STRIPS	6.90	0.88	6.20	1.69	6.55	1.36
	E_STRIPS	5.25	1.50	6.75	0.50	6.00	1.31
	C_WORK	3.00	1.25	3.00	2.36	3.00	1.84
	R_WORK	3.10	1.45	3.10	1.66	3.10	1.52
	E_WORK	4.75	0.96	3.50	1.00	4.13	1.13

SCENARIO 3
Controller Post-Run Data

			Position				**Group Total**	
			R		**D**		**Mean**	**Std. Dev.**
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**		
SECTOR	R60/62/63	C_AWARE	7.40	0.89	6.40	1.82	6.90	1.45
		R_AWARE	7.40	0.55	7.40	0.55	7.40	0.52
		C_COMM	8.00	0.00	7.40	0.55	7.70	0.48
		R_COMM	8.00	0.00	7.80	0.45	7.90	0.32
		C_COMPUT	7.20	1.30	7.20	0.45	7.20	0.92
		R_COMPUT	7.20	1.30	7.40	0.55	7.30	0.95
		C_COMTOT	104.40	25.68	79.00	19.24	91.70	25.23
		R_COMTOT	97.20	12.58	75.20	28.15	86.20	23.60
		C_COORD	7.80	0.45	7.40	0.55	7.60	0.52
		R_COORD	7.40	0.89	7.80	0.45	7.60	0.70
		C_PRIOR	7.60	0.89	7.20	0.84	7.40	0.84
		R_PRIOR	7.60	0.55	7.60	0.55	7.60	0.52
		C_SEPAR	8.00	0.00	7.20	0.84	7.60	0.70
		R_SEPAR	7.60	0.89	7.80	0.45	7.70	0.67
		C_STRIPS	7.20	0.84	7.20	0.84	7.20	0.79
		R_STRIPS	7.20	0.84	7.60	0.55	7.40	0.70
		C_WORK	2.40	1.14	2.60	2.51	2.50	1.84

		R_WORK	2.40	0.89	2.60	2.51	2.50	1.78
	R1	C_AWARE	6.20	0.84	6.40	1.52	6.30	1.16
		R_AWARE	5.00	1.41	5.80	1.92	5.40	1.65
		C_COMM	7.20	0.45	7.00	1.00	7.10	0.74
		R_COMM	6.20	0.84	6.40	1.95	6.30	1.42
		C_COMPUT	5.80	2.17	7.40	0.55	6.60	1.71
		R_COMPUT	5.60	1.67	7.20	0.84	6.40	1.51
		C_COMTOT	133.40	21.24	44.00	12.39	88.70	49.89
		R_COMTOT	142.40	10.29	50.40	9.79	96.40	49.40
		C_COORD	6.40	1.34	6.20	1.92	6.30	1.57
		R_COORD	4.80	1.30	7.20	0.45	6.00	1.56
		C_PRIOR	6.40	0.89	7.00	0.00	6.70	0.67
		R_PRIOR	6.20	0.84	7.00	0.00	6.60	0.70
		C_SEPAR	7.00	1.00	7.60	0.55	7.30	0.82
		R_SEPAR	5.00	1.41	6.00	2.00	5.50	1.72
		C_STRIPS	4.60	0.89	6.80	0.84	5.70	1.42
		R_STRIPS	4.20	2.17	6.80	0.84	5.50	2.07
		C_WORK	2.80	0.84	2.80	1.10	2.80	0.92
		R_WORK	4.00	1.87	4.40	1.14	4.20	1.48
Group Total		C_AWARE	6.80	1.03	6.40	1.58	6.60	1.31
		R_AWARE	6.20	1.62	6.60	1.58	6.40	1.57
		C_COMM	7.60	0.52	7.20	0.79	7.40	0.68
		R_COMM	7.10	1.10	7.10	1.52	7.10	1.29
		C_COMPUT	6.50	1.84	7.30	0.48	6.90	1.37
		R_COMPUT	6.40	1.65	7.30	0.67	6.85	1.31
		C_COMTOT	118.90	26.97	61.50	23.94	90.20	38.51
		R_COMTOT	119.80	26.17	62.80	23.78	91.30	38.04
		C_COORD	7.10	1.20	6.80	1.48	6.95	1.32
		R_COORD	6.10	1.73	7.50	0.53	6.80	1.44
		C_PRIOR	7.00	1.05	7.10	0.57	7.05	0.83
		R_PRIOR	6.90	0.99	7.30	0.48	7.10	0.79
		C_SEPAR	7.50	0.85	7.40	0.70	7.45	0.76
		R_SEPAR	6.30	1.77	6.90	1.66	6.60	1.70
		C_STRIPS	5.90	1.60	7.00	0.82	6.45	1.36
		R_STRIPS	5.70	2.21	7.20	0.79	6.45	1.79
		C_WORK	2.60	.97	2.70	1.83	2.65	1.42
		R_WORK	3.20	1.62	3.50	2.07	3.35	1.81

SCENARIO 4
Controller Post-Run Data

	Position						Group Total	
	R		D		A		Mean	Std. Dev.
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.		
C_AWARE	4.80	2.17	6.60	1.67	6.60	2.07	6.00	2.04
R_AWARE	4.60	1.95	5.80	1.10	5.40	1.82	5.27	1.62
E_AWARE	3.50	1.00	5.50	2.38	5.25	2.22	4.75	2.01
C_COMM	6.00	2.24	7.80	0.45	7.25	0.96	7.00	1.57
R_COMM	7.00	0.71	7.80	0.45	7.60	0.55	7.47	0.64
E_COMM	5.00	1.15	6.25	1.71	7.25	0.96	6.17	1.53
C_COMPUT	6.60	0.55	7.40	0.89	7.67	0.58	7.15	0.80
R_COMPUT	6.20	0.84	7.20	0.84	7.50	0.71	6.83	0.94
E_COMPUT	4.25	1.26	7.25	0.96	7.00	1.41	6.17	1.80
C_COMTOT	166.60	31.16	133.40	45.47	17.80	11.12	105.93	72.54
R_COMTOT	171.40	50.26	140.60	22.68	29.80	10.71	113.93	69.73
E_COMTOT	209.25	48.26	101.75	30.97	78.75	29.75	129.92	68.32
C_COORD	5.80	2.17	7.80	0.45	7.75	0.50	7.07	1.59
R_COORD	6.40	0.89	6.80	1.30	6.40	0.55	6.53	0.92
E_COORD	4.25	2.22	6.75	1.89	6.50	1.29	5.83	2.04
C_PRIOR	6.80	0.84	7.60	0.55	7.33	1.15	7.23	0.83
R_PRIOR	6.20	1.48	7.40	0.55	7.25	0.96	6.93	1.14
E_PRIOR	4.75	0.96	7.25	0.50	6.25	2.22	6.08	1.68
C_SEPAR	7.40	0.89	8.00	0.00	7.50	0.71	7.67	0.65
R_SEPAR	7.00	1.22	7.20	0.84	7.50	0.71	7.17	0.94
E_SEPAR	3.00	1.15	6.50	1.73	5.50	3.54	4.90	2.38
C_STRIPS	5.20	1.48	6.80	0.84	7.75	0.50	6.50	1.45
R_STRIPS	4.80	2.49	5.80	1.64	6.25	2.22	5.57	2.06
E_STRIPS	2.00	0.82	4.75	2.87	5.00	2.94	3.92	2.61
C_WORK	4.00	2.35	4.00	2.45	2.00	1.73	3.33	2.26
R_WORK	5.40	1.52	4.20	1.48	4.60	1.95	4.73	1.62
E_WORK	7.75	0.50	5.50	3.00	4.75	2.06	6.00	2.34

SCENARIO 1
Controller Interval Data

			Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
SECTOR	R63	C_WORK	1.70	0.98	1.75	1.07	1.73	1.01
		R_WORK	2.15	1.35	1.90	1.12	2.03	1.23
		E_WORK	3.83	2.33	3.75	1.82	3.79	2.04
	R60	C_WORK	1.35	0.59	1.20	0.41	1.27	0.51
		R_WORK	1.65	1.18	1.40	0.82	1.53	1.01
		E_WORK	3.67	2.10	3.50	2.07	3.58	2.04
Group Total		C_WORK	1.53	0.82	1.48	0.85	1.50	0.83
		R_WORK	1.90	1.28	1.65	1.00	1.78	1.15
		E_WORK	3.75	2.17	3.63	1.91	3.69	2.02

SCENARIO 2

Controller Interval Data

			Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
Sector	R60	C_WORK	2.40	1.82	2.30	1.59	2.35	1.69
		R_WORK	2.45	1.67	2.15	1.42	2.30	1.54
		E_WORK	2.50	1.51	2.88	1.55	2.69	1.49
	R62/63	C_WORK	2.15	1.90	2.25	1.86	2.20	1.86
		R_WORK	3.10	2.00	3.15	1.93	3.13	1.94
		E_WORK	3.63	1.85	2.75	1.39	3.19	1.64
Group Total		C_WORK	2.28	1.84	2.28	1.71	2.28	1.76
		R_WORK	2.78	1.85	2.65	1.75	2.71	1.79
		E_WORK	3.06	1.73	2.81	1.42	2.94	1.56

SCENARIO 3

Controller Interval Data

			Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
Sector	R60/62/63	C_WORK	1.85	1.04	2.55	1.79	2.20	1.49
		R_WORK	2.25	1.37	2.10	1.52	2.17	1.43
	R1	C_WORK	2.10	1.21	2.05	1.15	2.08	1.16
		R_WORK	3.05	1.82	2.65	1.42	2.85	1.63
Group Total		C_WORK	1.98	1.12	2.30	1.51	2.14	1.33
		R_WORK	2.65	1.64	2.38	1.48	2.51	1.56

SCENARIO 4

Controller Interval Data

	Position						Group Total	
	R		D		A		Mean	Std. Dev.
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.		
C_WORK	3.90	2.13	3.95	2.31	2.00	1.72	3.28	2.23
R_WORK	4.20	2.44	4.70	2.08	2.50	1.50	3.80	2.22
E_WORK	4.30	3.02	3.80	2.57	3.10	2.51	3.73	2.66

SCENARIO 1
T/O Post-Run Data

			Control Position				**Group Total**	
			R		**D**		**Mean**	**Std. Dev.**
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**		
SECTOR	R63	C_AWARE	7.50	0.58	7.80	0.45	7.67	0.50
		R_AWARE	6.60	1.14	7.00	1.22	6.80	1.14
		E_AWARE	6.67	1.53	6.33	1.53	6.50	1.38
		C_COMM	7.40	0.55	7.40	0.89	7.40	0.70
		R_COMM	7.20	1.10	7.00	1.41	7.10	1.20
		E_COMM	7.00	1.00	7.00	1.00	7.00	0.89
		C_COMPUT	7.60	0.55	7.80	0.45	7.70	0.48
		R_COMPUT	7.40	0.55	7.40	0.55	7.40	0.52
		E_COMPUT	7.67	0.58	7.67	0.58	7.67	0.52
		C_COORD	7.80	0.45	8.00	0.00	7.90	0.32
		R_COORD	7.60	0.89	7.00	1.00	7.30	0.95
		E_COORD	7.33	0.58	6.67	0.58	7.00	0.63
		C_STRIPS	7.20	0.84	7.40	0.55	7.30	0.67
		R_STRIPS	4.80	3.11	5.80	1.79	5.30	2.45
		E_STRIPS	5.33	2.31	5.67	2.08	5.50	1.97
		C_PRIOR	7.20	1.30	7.40	0.89	7.30	1.06
		R_PRIOR	7.00	1.73	7.75	0.50	7.33	1.32
		E_PRIOR	6.67	1.15	6.67	1.15	6.67	1.03
		C_SEPAR	8.00	0.00	7.80	0.45	7.89	0.33
		R_SEPAR	7.20	1.79	7.60	0.89	7.40	1.35
		E_SEPAR	7.67	0.58	8.00	0.00	7.83	0.41
		C_WORK	2.40	1.34	2.40	1.34	2.40	1.26
		R_WORK	3.60	0.89	4.00	1.22	3.80	1.03
		E_WORK	6.33	1.53	6.67	0.58	6.50	1.05
	R60	C_AWARE	7.20	0.84	7.40	0.55	7.30	0.67
		R_AWARE	7.20	1.30	7.60	0.55	7.40	0.97
		E_AWARE	4.67	1.53	4.67	2.31	4.67	1.75
		C_COMM	7.60	0.55	7.80	0.45	7.70	0.48
		R_COMM	7.60	0.55	7.00	2.24	7.30	1.57
		E_COMM	6.67	0.58	7.00	0.00	6.83	0.41
		C_COMPUT	7.20	0.84	7.20	1.10	7.20	0.92
		R_COMPUT	8.00	0.00	8.00	0.00	8.00	0.00
		E_COMPUT	7.33	0.58	7.33	0.58	7.33	0.52
		C_COORD	7.20	1.10	7.60	0.55	7.40	0.84
		R_COORD	7.75	0.50	7.00	1.41	7.38	1.06

		E_COORD	6.67	0.58	6.33	0.58	6.50	0.55
		C_STRIPS	7.60	0.55	7.60	0.55	7.60	0.52
		R_STRIPS	7.60	0.55	7.20	1.10	7.40	0.84
		E_STRIPS	4.33	2.08	4.67	2.31	4.50	1.97
		C_PRIOR	7.80	0.45	7.60	0.89	7.70	0.67
		R_PRIOR	7.80	0.45	7.80	0.45	7.80	0.42
		E_PRIOR	7.00	1.00	7.00	1.00	7.00	0.89
		C_SEPAR	8.00	0.00	8.00	0.00	8.00	0.00
		R_SEPAR	8.00	0.00	8.00	0.00	8.00	0.00
		E_SEPAR	4.67	2.31	5.33	2.89	5.00	2.37
		C_WORK	2.00	1.22	2.20	1.30	2.10	1.20
		R_WORK	2.20	0.84	2.40	1.52	2.30	1.16
		E_WORK	6.00	1.00	5.33	2.08	5.67	1.51
Group Total		C_AWARE	7.33	0.71	7.60	0.52	7.47	0.61
		R_AWARE	6.90	1.20	7.30	0.95	7.10	1.07
		E_AWARE	5.67	1.75	5.50	1.97	5.58	1.78
		C_COMM	7.50	0.53	7.60	0.70	7.55	0.60
		R_COMM	7.40	0.84	7.00	1.76	7.20	1.36
		E_COMM	6.83	0.75	7.00	0.63	6.92	0.67
		C_COMPUT	7.40	0.70	7.50	0.85	7.45	0.76
		R_COMPUT	7.70	0.48	7.70	0.48	7.70	0.47
		E_COMPUT	7.50	0.55	7.50	0.55	7.50	0.52
		C_COORD	7.50	0.85	7.80	0.42	7.65	0.67
		R_COORD	7.67	0.71	7.00	1.12	7.33	0.97
		E_COORD	7.00	0.63	6.50	0.55	6.75	0.62
		C_STRIPS	7.40	0.70	7.50	0.53	7.45	0.60
		R_STRIPS	6.20	2.57	6.50	1.58	6.35	2.08
		E_STRIPS	4.83	2.04	5.17	2.04	5.00	1.95
		C_PRIOR	7.50	0.97	7.50	0.85	7.50	0.89
		R_PRIOR	7.40	1.26	7.78	0.44	7.58	0.96
		E_PRIOR	6.83	0.98	6.83	0.98	6.83	0.94
		C_SEPAR	8.00	0.00	7.90	0.32	7.95	0.23
		R_SEPAR	7.60	1.26	7.80	0.63	7.70	0.98
		E_SEPAR	6.17	2.23	6.67	2.34	6.42	2.19
		C_WORK	2.20	1.23	2.30	1.25	2.25	1.21
		R_WORK	2.90	1.10	3.20	1.55	3.05	1.32
		E_WORK	6.17	1.17	6.00	1.55	6.08	1.31

SCENARIO 2
T/O Post-Run Data

			Control Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
SECTOR	R60	C_AWARE	7.20	1.10	7.40	1.34	7.30	1.16
		R_AWARE	7.20	1.30	6.80	1.30	7.00	1.25
		E_AWARE	4.50	2.12	4.00	4.24	4.25	2.75
		C_COMM	7.60	0.55	7.60	0.55	7.60	0.52
		R_COMM	7.20	0.84	7.60	0.55	7.40	0.70
		E_COMM	6.50	2.12	6.50	2.12	6.50	1.73
		C_COMPUT	7.60	0.89	7.80	0.45	7.70	0.67
		R_COMPUT	7.60	0.55	7.80	0.45	7.70	0.48
		E_COMPUT	7.50	0.71	7.50	0.71	7.50	0.58
		C_COORD	7.40	0.89	7.60	0.89	7.50	0.85
		R_COORD	7.40	0.55	7.40	0.89	7.40	0.70
		E_COORD	5.00	1.41	7.50	0.71	6.25	1.71
		C_STRIPS	6.60	0.89	7.00	1.22	6.80	1.03
		R_STRIPS	6.40	0.89	7.00	1.73	6.70	1.34
		E_STRIPS	6.00	2.83	7.00	1.41	6.50	1.91
		C_PRIOR	7.80	0.45	7.60	0.89	7.70	0.67
		R_PRIOR	8.00	0.00	7.80	0.45	7.90	0.32
		E_PRIOR	5.50	2.12	6.00	1.41	5.75	1.50
		C_SEPAR	7.80	0.45	7.80	0.45	7.80	0.42
		R_SEPAR	8.00	0.00	8.00	0.00	8.00	0.00
		E_SEPAR	2.50	0.71	4.50	4.95	3.50	3.11
		C_WORK	3.80	1.64	4.00	1.87	3.90	1.66
		R_WORK	3.60	2.07	3.80	2.05	3.70	1.95
		E_WORK	6.50	0.71	5.50	0.71	6.00	0.82
	R62/63	C_AWARE	7.40	0.89	6.40	1.52	6.90	1.29
		R_AWARE	7.20	0.84	6.40	1.67	6.80	1.32
		E_AWARE	7.00	0.00	7.00	0.00	7.00	0.00
		C_COMM	7.40	0.89	7.40	0.89	7.40	0.84
		R_COMM	7.60	0.55	7.60	0.55	7.60	0.52
		E_COMM	7.50	0.71	8.00	0.00	7.75	0.50
		C_COMPUT	7.20	0.84	7.40	0.55	7.30	0.67
		R_COMPUT	7.80	0.45	7.80	0.45	7.80	0.42
		E_COMPUT	6.50	0.71	7.00	0.00	6.75	0.50
		C_COORD	7.40	0.89	6.40	2.07	6.90	1.60
		R_COORD	7.20	0.84	6.40	1.52	6.80	1.23

		E_COORD	7.50	0.71	7.50	0.71	7.50	0.58
		C_STRIPS	6.60	1.67	6.00	2.45	6.30	2.00
		R_STRIPS	7.20	0.84	6.60	1.52	6.90	1.20
		E_STRIPS	7.00	1.41	7.00	1.41	7.00	1.15
		C_PRIOR	7.40	0.89	7.20	0.84	7.30	0.82
		R_PRIOR	7.20	0.84	7.60	0.55	7.40	0.70
		E_PRIOR	7.50	0.71	7.50	0.71	7.50	0.58
		C_SEPAR	7.60	0.89	7.80	0.45	7.70	0.67
		R_SEPAR	7.60	0.55	7.80	0.45	7.70	0.48
		E_SEPAR	7.50	0.71	7.50	0.71	7.50	0.58
		C_WORK	4.20	2.28	5.00	2.45	4.60	2.27
		R_WORK	3.60	1.95	4.00	2.12	3.80	1.93
		E_WORK	3.00	1.41	3.50	0.71	3.25	0.96
Group Total		C_AWARE	7.30	0.95	6.90	1.45	7.10	1.21
		R_AWARE	7.20	1.03	6.60	1.43	6.90	1.25
		E_AWARE	5.75	1.89	5.50	3.00	5.63	2.33
		C_COMM	7.50	0.71	7.50	0.71	7.50	0.69
		R_COMM	7.40	0.70	7.60	0.52	7.50	0.61
		E_COMM	7.00	1.41	7.25	1.50	7.13	1.36
		C_COMPUT	7.40	0.84	7.60	0.52	7.50	0.69
		R_COMPUT	7.70	0.48	7.80	0.42	7.75	0.44
		E_COMPUT	7.00	0.82	7.25	0.50	7.13	0.64
		C_COORD	7.40	0.84	7.00	1.63	7.20	1.28
		R_COORD	7.30	0.67	6.90	1.29	7.10	1.02
		E_COORD	6.25	1.71	7.50	0.58	6.88	1.36
		C_STRIPS	6.60	1.26	6.50	1.90	6.55	1.57
		R_STRIPS	6.80	0.92	6.80	1.55	6.80	1.24
		E_STRIPS	6.50	1.91	7.00	1.15	6.75	1.49
		C_PRIOR	7.60	0.70	7.40	0.84	7.50	0.76
		R_PRIOR	7.60	0.70	7.70	0.48	7.65	0.59
		E_PRIOR	6.50	1.73	6.75	1.26	6.63	1.41
		C_SEPAR	7.70	0.67	7.80	0.42	7.75	0.55
		R_SEPAR	7.80	0.42	7.90	0.32	7.85	0.37
		E_SEPAR	5.00	2.94	6.00	3.37	5.50	2.98
		C_WORK	4.00	1.89	4.50	2.12	4.25	1.97
		R_WORK	3.60	1.90	3.90	1.97	3.75	1.89
		E_WORK	4.75	2.22	4.50	1.29	4.63	1.69

SCENARIO 3
T/O Post-Run Data

			Control Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
SECTOR	R60/62/63	C_AWARE	7.20	0.45	7.00	1.00	7.10	0.74
		R_AWARE	7.40	0.55	7.10	1.19	7.25	0.89
		C_COMM	7.30	0.27	7.20	0.67	7.25	0.49
		R_COMM	7.30	0.27	7.22	0.41	7.26	0.33
		C_COMPUT	7.40	0.42	7.50	0.35	7.45	0.37
		R_COMPUT	7.30	0.84	7.20	0.84	7.25	0.79
		C_COORD	7.40	0.42	7.20	0.67	7.30	0.54
		R_COORD	7.50	0.35	7.30	0.76	7.40	0.57
		C_STRIPS	6.90	0.65	6.90	1.08	6.90	0.84
		R_STRIPS	6.90	0.42	6.80	0.91	6.85	0.67
		C_PRIOR	7.60	0.22	7.50	0.35	7.55	0.28
		R_PRIOR	7.30	0.45	7.40	0.55	7.35	0.47
		C_SEPAR	8.00	0.00	7.50	1.12	7.75	0.79
		R_SEPAR	7.70	0.45	7.70	0.45	7.70	0.42
		C_WORK	3.90	1.56	4.30	2.08	4.10	1.74
		R_WORK	3.60	1.52	3.80	1.79	3.70	1.57
	R1	C_AWARE	7.20	0.84	7.40	0.55	7.30	0.67
		R_AWARE	6.20	1.64	5.80	1.79	6.00	1.63
		C_COMM	7.80	0.45	7.80	0.45	7.80	0.42
		R_COMM	6.60	2.07	5.40	3.21	6.00	2.62
		C_COMPUT	7.60	0.89	7.80	0.45	7.70	0.67
		R_COMPUT	7.20	0.84	7.60	0.55	7.40	0.70
		C_COORD	7.80	0.45	7.60	0.89	7.70	0.67
		R_COORD	7.40	0.89	7.40	0.89	7.40	0.84
		C_STRIPS	7.20	1.30	7.60	0.89	7.40	1.07
		R_STRIPS	6.60	1.14	6.80	1.30	6.70	1.16
		C_PRIOR	7.00	0.71	7.20	0.84	7.10	0.74
		R_PRIOR	6.40	1.95	6.80	1.10	6.60	1.51
		C_SEPAR	7.20	1.10	7.40	0.89	7.30	0.95
		R_SEPAR	6.20	2.05	5.60	2.51	5.90	2.18
		C_WORK	3.00	1.22	3.00	1.41	3.00	1.25
		R_WORK	4.00	1.41	4.40	1.34	4.20	1.32

Group Total	C_AWARE	7.20	0.63	7.20	0.79	7.20	0.70
	R_AWARE	6.80	1.32	6.45	1.59	6.63	1.43
	C_COMM	7.55	0.44	7.50	0.62	7.53	0.53
	R_COMM	6.95	1.44	6.31	2.36	6.63	1.93
	C_COMPUT	7.50	0.67	7.65	0.41	7.58	0.54
	R_COMPUT	7.25	0.79	7.40	0.70	7.33	0.73
	C_COORD	7.60	0.46	7.40	0.77	7.50	0.63
	R_COORD	7.45	0.64	7.35	0.78	7.40	0.70
	C_STRIPS	7.05	0.98	7.25	1.01	7.15	0.97
	R_STRIPS	6.75	0.82	6.80	1.06	6.78	0.92
	C_PRIOR	7.30	0.59	7.35	0.63	7.33	0.59
	R_PRIOR	6.85	1.42	7.10	0.88	6.98	1.15
	C_SEPAR	7.60	0.84	7.45	0.96	7.53	0.88
	R_SEPAR	6.95	1.61	6.65	2.03	6.80	1.79
	C_WORK	3.45	1.40	3.65	1.81	3.55	1.58
	R_WORK	3.80	1.40	4.10	1.52	3.95	1.43

SCENARIO 4
T/O Post-Run Data

	Control Position						**Group Total**	
	R		**D**		**A**		**Mean**	**Std. Dev.**
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**		
C_AWARE	6.20	0.97	5.80	1.92	7.25	0.96	6.36	1.42
R_AWARE	5.50	1.41	5.60	1.67	6.80	1.10	5.97	1.45
E_AWARE	3.63	1.11	3.75	2.22	5.25	2.63	4.21	2.04
C_COMM	7.20	0.67	7.40	0.89	7.75	0.50	7.43	0.70
R_COMM	7.10	0.65	7.40	0.89	7.60	0.55	7.37	0.69
E_COMM	6.13	1.93	7.50	0.58	7.75	0.50	7.13	1.32
C_COMPUT	6.80	1.04	6.80	1.64	7.33	1.15	6.92	1.24
R_COMPUT	7.10	0.42	7.40	0.89	7.50	0.58	7.32	0.64
E_COMPUT	5.25	1.26	7.25	0.96	7.67	0.58	6.64	1.43
C_COORD	6.90	0.42	7.20	1.10	8.00	0.00	7.32	0.80
R_COORD	6.70	1.04	6.40	1.14	7.20	0.84	6.77	1.00
E_COORD	5.50	1.29	5.75	2.22	7.25	0.96	6.17	1.64
C_STRIPS	5.80	0.97	4.80	2.77	7.00	1.41	5.79	1.99
R_STRIPS	5.10	1.56	4.40	2.61	7.00	1.41	5.39	2.12
E_STRIPS	3.75	1.66	3.50	3.00	6.00	1.73	4.27	2.32
C_PRIOR	7.00	0.35	7.00	1.00	7.75	0.50	7.21	0.73
R_PRIOR	7.00	0.61	7.00	0.71	7.50	0.58	7.14	0.63
E_PRIOR	5.00	1.58	5.25	2.63	6.33	2.08	5.45	2.01

C_SEPAR	7.00	1.00	6.00	2.12	7.33	1.15	6.69	1.55
R_SEPAR	6.50	1.46	6.75	0.96	8.00	0.00	6.96	1.20
E_SEPAR	3.25	1.19	5.00	2.58	6.67	2.31	4.82	2.35
C_WORK	4.80	0.76	5.00	1.87	2.60	1.52	4.13	1.76
R_WORK	5.50	1.46	6.00	1.22	4.00	1.87	5.17	1.68
E_WORK	6.88	0.85	7.25	0.50	5.00	1.63	6.38	1.43

SCENARIO 1
T/O Interval Data

			Control Position				**Group Total**	
			R		**D**		**Mean**	**Std. Dev.**
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**		
SECTOR	R63	C_WORK	2.10	1.48	2.20	1.47	2.15	1.46
		R_WORK	2.70	1.49	2.70	1.75	2.70	1.60
		E_WORK	4.25	2.45	4.58	2.02	4.42	2.21
	R60	C_WORK	1.75	0.85	1.75	0.85	1.75	0.84
		R_WORK	1.65	0.81	1.60	0.75	1.63	0.77
		E_WORK	4.00	2.37	3.58	2.27	3.79	2.28
Group Total		C_WORK	1.93	1.21	1.98	1.21	1.95	1.20
		R_WORK	2.17	1.30	2.15	1.44	2.16	1.36
		E_WORK	4.13	2.36	4.08	2.17	4.10	2.24

SCENARIO 2
T/O Interval Data

			Control Position				**Group Total**	
			R		**D**		**Mean**	**Std. Dev.**
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**		
SECTOR	R60	C_WORK	2.80	1.79	2.50	1.57	2.65	1.67
		R_WORK	2.45	1.50	2.45	1.39	2.45	1.43
		E_WORK	3.63	2.39	4.00	1.77	3.81	2.04
	R62/63	C_WORK	2.65	1.90	3.00	1.92	2.83	1.89
		R_WORK	2.65	1.50	3.05	1.88	2.85	1.69
		E_WORK	3.00	1.69	3.38	1.60	3.19	1.60
Group Total		C_WORK	2.73	1.83	2.75	1.75	2.74	1.78
		R_WORK	2.55	1.48	2.75	1.66	2.65	1.57
		E_WORK	3.31	2.02	3.69	1.66	3.50	1.83

SCENARIO 3
T/O Interval Data

			Control Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
SECTOR	R60/62/63	C_WORK	2.35	1.41	2.55	1.66	2.45	1.52
		R_WORK	2.50	1.56	2.55	1.70	2.53	1.61
	R1	C_WORK	2.25	1.41	2.05	1.39	2.15	1.39
		R_WORK	2.53	1.52	2.90	2.02	2.71	1.78
Group Total		C_WORK	2.30	1.39	2.30	1.54	2.30	1.46
		R_WORK	2.51	1.52	2.73	1.85	2.62	1.69

SCENARIO 4
T/O Interval Data

	Control Position						Group Total	
	R		D		A		Mean	Std. Dev.
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.		
C_WORK	3.60	1.91	3.90	2.25	1.90	1.55	3.13	2.09
R_WORK	3.95	2.33	4.25	1.89	1.95	1.32	3.38	2.12
E_WORK	5.34	2.77	5.31	2.98	3.94	2.49	4.86	2.77

SCENARIO 1
SAR Data

			Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
SECTOR	R63	C_QN	127.20	23.09	0.00	0.00	63.60	68.79
		R_QN	118.40	22.79	0.00	0.00	59.20	64.22
		E_QN	74.00	64.21	0.00	0.00	37.00	57.38
		C_QT	15.20	5.02	0.00	0.00	7.60	8.68
		R_QT	14.20	3.11	0.00	0.00	7.10	7.77
		E_QT	5.00	4.36	0.00	0.00	2.50	3.89
		C_QU	6.80	2.77	5.60	3.85	6.20	3.22
		R_QU	6.20	2.68	5.80	3.27	6.00	2.83
		E_QU	5.00	4.58	1.33	1.53	3.17	3.66
		C_QX	4.60	1.67	0.20	0.45	2.40	2.59
		R_QX	4.00	1.22	0.60	0.89	2.30	2.06
		E_QX	1.67	1.53	0.00	0.00	0.83	1.33
		C_QZ	5.40	0.89	10.60	13.43	8.00	9.38
		R_QZ	7.20	2.49	7.80	9.15	7.50	6.33
		E_QZ	7.67	6.81	4.33	5.86	6.00	5.97
	R60	C_QN	123.00	28.52	0.00	0.00	61.50	67.56
		R_QN	98.40	5.55	0.00	0.00	49.20	51.99
		E_QN	75.67	71.46	0.00	0.00	37.83	61.32
		C_QT	11.60	4.56	0.20	0.45	5.90	6.74
		R_QT	8.20	0.84	0.20	0.45	4.20	4.26
		E_QT	2.67	2.52	0.00	0.00	1.33	2.16

		C_QU	10.60	9.71	10.40	6.54	10.50	7.81
		R_QU	12.00	4.06	7.40	4.93	9.70	4.90
		E_QU	9.00	7.94	7.00	6.56	8.00	6.60
		C_QX	2.80	1.92	0.20	0.45	1.50	1.90
		R_QX	1.40	0.89	0.20	0.45	0.80	.92
		E_QX	3.33	2.89	0.00	0.00	1.67	2.58
		C_QZ	8.00	2.35	12.40	7.44	10.20	5.69
		R_QZ	11.80	1.30	12.20	8.26	12.00	5.58
		E_QZ	5.67	6.03	6.00	7.94	5.83	6.31
Group Total		C_QN	125.10	24.56	0.00	0.00	62.55	66.36
		R_QN	108.40	18.86	0.00	0.00	54.20	57.10
		E_QN	74.83	60.77	0.00	0.00	37.42	56.62
		C_QT	13.40	4.90	0.10	0.32	6.75	7.61
		R_QT	11.20	3.82	0.10	0.32	5.65	6.28
		E_QT	3.83	3.43	0.00	0.00	1.92	3.06
		C_QU	8.70	7.02	8.00	5.66	8.35	6.22
		R_QU	9.10	4.46	6.60	4.03	7.85	4.33
		E_QU	7.00	6.20	4.17	5.27	5.58	5.68
		C_QX	3.70	1.95	0.20	0.42	1.95	2.26
		R_QX	2.70	1.70	0.40	0.70	1.55	1.73
		E_QX	2.50	2.26	0.00	0.00	1.25	2.01
		C_QZ	6.70	2.16	11.50	10.28	9.10	7.64
		R_QZ	9.50	3.06	10.00	8.54	9.75	6.25
		E_QZ	6.67	5.85	5.17	6.31	5.92	5.85

SCENARIO 2
SAR Data

			Position				**Group Total**	
			R		**D**		**Mean**	**Std. Dev.**
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**		
SECTOR	R60	C_QN	99.60	57.57	0.00	0.00	49.80	65.03
		R_QN	131.33	13.20	0.00	0.00	65.67	72.42
		E_QN	140.00	.	0.00	.	70.00	98.99
		C_QT	7.60	4.77	0.00	0.00	3.80	5.12
		R_QT	8.67	2.08	0.00	0.00	4.33	4.93
		E_QT	4.00	.	0.00	.	2.00	2.83
		C_QU	11.00	7.07	3.60	4.39	7.30	6.78
		R_QU	14.33	5.13	2.67	2.31	8.50	7.31
		E_QU	6.00	.	6.00	.	6.00	0.00
		C_QX	3.00	2.00	0.00	0.00	1.50	2.07
		R_QX	2.33	0.58	0.00	0.00	1.17	1.33
		E_QX	4.00	.	0.00	.	2.00	2.83
		C_QZ	6.40	4.39	9.60	15.65	8.00	10.96
		R_QZ	10.67	1.15	4.67	3.79	7.67	4.13
		E_QZ	9.00	.	1.00	.	5.00	5.66
	R62/63	C_QN	92.40	53.20	0.00	0.00	46.20	60.25
		R_QN	65.33	56.72	0.00	0.00	32.67	50.67
		E_QN	85.00	.	0.00	.	42.50	60.10
		C_QT	15.60	11.33	0.00	0.00	7.80	11.16
		R_QT	11.00	9.85	0.00	0.00	5.50	8.67
		E_QT	11.00	.	0.00	.	5.50	7.78
		C_QU	10.00	6.89	0.40	0.55	5.20	6.84
		R_QU	7.00	8.19	0.33	0.58	3.67	6.35

		E_QU	11.00	.	0.00	.	5.50	7.78
		C_QX	5.00	2.92	0.40	0.55	2.70	3.13
		R_QX	4.67	4.16	0.00	0.00	2.33	3.67
		E_QX	9.00	.	0.00	.	4.50	6.36
		C_QZ	2.60	1.95	0.60	0.55	1.60	1.71
		R_QZ	4.67	4.04	1.33	2.31	3.00	3.46
		E_QZ	6.00	.	2.00	.	4.00	2.83
Group Total		C_QN	96.00	52.40	0.00	0.00	48.00	61.04
		R_QN	98.33	51.61	0.00	0.00	49.17	62.03
		E_QN	112.50	38.89	0.00	0.00	56.25	68.72
		C_QT	11.60	9.22	0.00	0.00	5.80	8.70
		R_QT	9.83	6.49	0.00	0.00	4.92	6.75
		E_QT	7.50	4.95	0.00	0.00	3.75	5.19
		C_QU	10.50	6.60	2.00	3.40	6.25	6.72
		R_QU	10.67	7.31	1.50	1.97	6.08	7.00
		E_QU	8.50	3.54	3.00	4.24	5.75	4.50
		C_QX	4.00	2.58	0.20	0.42	2.10	2.65
		R_QX	3.50	2.95	0.00	0.00	1.75	2.70
		E_QX	6.50	3.54	0.00	0.00	3.25	4.27
		C_QZ	4.50	3.78	5.10	11.46	4.80	8.31
		R_QZ	7.67	4.23	3.00	3.35	5.33	4.38
		E_QZ	7.50	2.12	1.50	0.71	4.50	3.70

SCENARIO 3
SAR Data

			Position				Group Total	
			R		D		Mean	Std. Dev.
			Mean	Std. Dev.	Mean	Std. Dev.		
SECTOR	R60/62/63	C_QN	115.50	20.66	0.00	0.00	57.75	63.20
		R_QN	71.33	61.98	0.00	0.00	35.67	55.34
		C_QT	13.50	4.20	0.00	0.00	6.75	7.72
		R_QT	7.00	6.08	0.00	0.00	3.50	5.43
		C_QU	15.00	3.16	4.50	4.36	9.75	6.63
		R_QU	10.67	11.02	8.00	3.46	9.33	7.45
		C_QX	3.25	.50	0.00	0.00	1.63	1.77
		R_QX	1.67	1.53	0.33	0.58	1.00	1.26
		C_QZ	6.00	2.71	1.75	1.50	3.88	3.04
		R_QZ	6.33	5.51	2.33	2.08	4.33	4.32
	R1	C_QN	120.25	9.18	0.00	0.00	60.13	64.56
		R_QN	115.33	5.86	0.00	0.00	57.67	63.28
		C_QT	5.75	2.06	1.25	1.89	3.50	3.02
		R_QT	6.33	3.51	1.33	1.53	3.83	3.66
		C_QU	8.00	3.37	4.25	5.32	6.13	4.58
		R_QU	7.00	2.65	5.00	7.81	6.00	5.33
		C_QX	1.25	1.50	0.25	0.50	0.75	1.16
		R_QX	1.00	1.00	0.00	0.00	0.50	0.84
		C_QZ	10.00	2.83	19.50	11.47	14.75	9.25
		R_QZ	10.33	3.06	20.67	12.90	15.50	10.11
Group Total		C_QN	117.88	15.02	0.00	0.00	58.94	61.73
		R_QN	93.33	46.16	0.00	0.00	46.67	57.83
		C_QT	9.63	5.15	0.63	1.41	5.13	5.91

	R_QT	6.67	4.46	0.67	1.21	3.67	4.42
	C_QU	11.50	4.81	4.38	4.50	7.94	5.81
	R_QU	8.83	7.44	6.50	5.65	7.67	6.41
	C_QX	2.25	1.49	0.13	0.35	1.19	1.52
	R_QX	1.33	1.21	0.17	0.41	0.75	1.06
	C_QZ	8.00	3.34	10.63	12.14	9.31	8.71
	R_QZ	8.33	4.55	11.50	13.00	9.92	9.43

SCENARIO 4
SAR Data

			Position				**Group Total**	
			R		**D**		**Mean**	**Std. Dev.**
			Mean	**Std. Dev.**	**Mean**	**Std. Dev.**		
SECTOR	R62/63	C_QN	113.67	14.57	0.00	0.00	56.83	62.94
		R_QN	117.00	17.26	0.00	0.00	58.50	63.55
		E_QN	114.33	6.11	0.00	0.00	57.17	62.74
		C_QT	22.33	0.58	0.00	0.00	11.17	12.24
		R_QT	29.50	5.92	1.25	2.50	15.38	15.67
		E_QT	19.67	3.06	5.00	8.66	12.33	9.91
		C_QU	10.67	6.43	2.00	3.46	6.33	6.62
		R_QU	10.50	7.33	3.75	4.99	7.13	6.83
		E_QU	6.67	3.06	1.67	2.89	4.17	3.82
		C_QX	8.33	1.15	1.00	1.73	4.67	4.23
		R_QX	7.50	1.29	2.00	1.63	4.75	3.24
		E_QX	6.33	0.58	1.00	1.73	3.67	3.14
		C_QZ	9.00	0.00	4.67	7.23	6.83	5.15
		R_QZ	12.25	1.26	21.25	27.83	16.75	18.86
		E_QZ	11.33	0.58	12.33	18.77	11.83	11.89
Group Total		C_QN	113.67	14.57	0.00	0.00	56.83	62.94
		R_QN	117.00	17.26	0.00	0.00	58.50	63.55
		E_QN	114.33	6.11	0.00	0.00	57.17	62.74
		C_QT	22.33	0.58	0.00	0.00	11.17	12.24
		R_QT	29.50	5.92	1.25	2.50	15.38	15.67
		E_QT	19.67	3.06	5.00	8.66	12.33	9.91
		C_QU	10.67	6.43	2.00	3.46	6.33	6.62
		R_QU	10.50	7.33	3.75	4.99	7.13	6.83
		E_QU	6.67	3.06	1.67	2.89	4.17	3.82
		C_QX	8.33	1.15	1.00	1.73	4.67	4.23
		R_QX	7.50	1.29	2.00	1.63	4.75	3.24
		E_QX	6.33	0.58	1.00	1.73	3.67	3.14
		C_QZ	9.00	0.00	4.67	7.23	6.83	5.15
		R_QZ	12.25	1.26	21.25	27.83	16.75	18.86
		E_QZ	11.33	0.58	12.33	18.77	11.83	11.89

APPENDIX E

Possible Conflicts Noted by the Technical Observers

Table E1 lists all the possible conflict situations recorded on the T/O form during the simulation. Situations were classified as operational errors or Deviations according to the 7110.65 Air Traffic Controller Handbook. "Situations" were denoted as "RVSM" if there was a separation violation that was not a violation under current standards but would have been under reduced vertical standards. The word "None" appears if a situation was recorded but did not fall into any of the previously mentioned categories. The day, scenario, sector, and interval for each situation are also listed. The last column of the table lists the control team responsible for the possible conflict and the total number of errors that particular team made for the day. For example, the Deviation listed in row one was made by control team K. On the 25th, team K had a total of 6 possible conflict situations.

Table E1. Possible Conflicts Noted by the T/Os

Day	Scenario	Sector	Interval	Situation Type	Explanation	Team-#Errors
25	1C	R60	2	Deviation	FL 310 coordinated on CUB484 but the strip was not cocked out.	K-6
25	1C	R60	3	Deviation	FL 330 coordinated on IBE620 but the strip was not angulated.	K-6
26	1C	R63	2	Error	BAW265 & LTU422 - BAW265 checked in at FL 330 with non radar traffic (LTU442) 4 minutes in-trail at FL 350 that was not identified or talking to ZMA. BAW265 climbed to FL 390 through the protected "push" of LTU442. (Non-radar error)	N-1
25	1C	R63	4	None	Two aircraft were head-on at FL 310. The controller took the proper action to resolve the conflict and also corrected the situation in a safe amount of time.	L-1
20	1E Radar	R60	3	Error	AAL638 & AAL509 - When radar outage occurred, AAL638 was at FL 330 and AAL509 was at FL 330. Both aircraft were proceeding direct ROBLE approximately 2 minutes in trail. Non-radar separation was never established.	G-2
20	1E Radar	R60	3	Error	CDN357 & AAL267 - CDN357 proceeded direct to ALBEE. AAL267 was at FL 330 on A315. The aircraft were radar separated at the time of the radar outage non-radar longitudinal separation of ten minutes in-trail was not established.	G-2
16	1E Radar	R60	4	Error	CUB944 & AAL638 - CUB944 was routed direct POTAR. AAL638 was routed direct ROBLE at WAFDOF (FL 350 climbed from FL 330). Controller did not request DME from any VOR to see if aircraft were laterally separated.	A-2
25	1E Weather	R60	2	Deviation	ROY173 was WAFDOF and the strip was not marked.	K-6

Day	Scenario	Sector	Interval	Situation Type	Explanation	Team-#Errors
25	1E Weather	R60	3	None	AAL638 & AAL507 - Controller took hand-off for AAL638, which was converging with AAL507 that was deviating because of weather. The controller took too long to resolve possible conflict.	K-6
25	1E Weather	R60	3	None	AAL509 & AAL638 - Potential conflict with AAL509 and AAL638. R side kept calling AAL509 AAL508.	K-6
25	1E Weather	R60	4	None	AAL507 & CON357 - Possible conflict. The controller never saw it.	K-6
26	2E Radar	R60	3	Error	AAL507 & AAL638 - AAL507 turned to GRATX at ZQA. It crossed in front of AAL638 at the same altitude without the required separation.	O-1
17	2E Weather	R60	3	Error	BAW297 & IBE621 - Aircraft were converging. IBE621 was at FL 330 and BAW297 was climbing to FL 350. The target touched the 5-mile buffer of the other aircraft. Closest proximity of 4.5 miles and 1,500 ft not in WATRS area.	B-1
19	3C	R60/62/63	N/G	Deviation	No track was started for DOA964. ACU522 had 2 altitudes written on the strip. Numerous aircraft did not have oceanic "over" circles.	E-3
19	3C	R60/62/63	N/G	Deviation	SUV605 - serve USA six hundred five.	E-3
16	3C	R60/62/63	2	Error	AAL57 & UAL053 - Both aircraft were over GRATX at FL 390 with only 5 minutes separation.	A-2
18	3R	R1	2	Error	CMM509 & AFL389 - CMM509 was southbound on AR3 at FL 350 (NUCAR time 00:21). AFL389 was inbound on A699 at FL 350 (NUCAR time 00:19).	C-2
18	3R	R1	2	Error	CMM509 & DLH464 - CMM509 was southbound on AR3 climbing to FL 370 (NUCAR time 00:21). DLH464 was inbound on A699 at FL 370 (NUCAR TIME 00:24).	C-2
20	3R	R1	2	Error	CMM509 & AFL389 - AFL389 was at FL 350 and CMM509 was at FL 350. AFL389 should have been at FL 330 as per coordination. Aircraft were less than 10 minutes apart.	H-1
19	3R	R60/62/63	N/G	Deviation	Controller issued EGF938 a clearance without stating an altitude.	E-3
24	4C	R62/63	2	Error	LTU420 & ROY173 - LTU420 was approved at WATRS boundary at FL 310. ROY173 was coming from SJU at FL 310. Both aircraft crossed within 4 minutes in non-radar airspace at 01:36.	J-8
24	4C	R62/63	2	Error	CKS869 & LHN861 - CKS869 was estimated over SEKAR at 02:28 at FL 330. LHN861 was estimated over SEKAR at 02:35 at FL 330. There was not enough time. It was done by the A-side.	J-8
23	4C	R62/63	3	Error	DART22 & M3389 - DART22 was at FL 370 over GEJAY and M3398 was over SLAPP at same time.	I-10
24	4C	R62/63	3	Error	SPP995 was southwest bound on B891 at FL 350 descending to FL 290 with non-radar traffic 8 minutes in-trail at FL 310. (Non-radar Error)	J-8

Day	Scenario	Sector	Interval	Situation Type	Explanation	Team-#Errors
25	4C	R62/63	3	Error	DOA474 & AJT840 - Controller climbed DOA474 through AJT840 and only had about 7 miles.	M-11
19	4E Radar	R62/63	N/G	Error	Too many operational errors to write down due to radar OTS	F-5
23	4E Radar	R62/63	N/G	Error	CMM314 & AAL141 - CMM314 over SLAPP at 22:48 and FL 400. AAL141 over FORD at 22:50 and also at FL 400. Fifteen degrees divergence was coordinated but R side issued direct SLAPP to CMM314, which nullified the 15-degree divergence.	I-10
23	4E Radar	R62/63	N/G	Deviation	USA041 wrong altitude for direction of flight not coordinated with New York.	I-10
18	4E Radar	R62/63	3	RVSM	RVSM // Controller assigned CMM 314 to FL 380 15 miles north of BOTES. Not RVSM airspace.	D-6
18	4E Radar	R62/63	3	RVSM	RVSM // Controller assigned AAL658 to FL 320 30 miles northeast of BOTES. (Not RVSM airspace)	D-6
19	4E	R62/63	3	Error	LHN892 & ACA956 - ACA956 was heading northbound on A554 at FL 350 and ACA956 was heading southbound on A554 at FL 350. Aircraft were converging.	F-1
19	4E Radar	R62/63	4	Error	VIA828 & AAL720 - VIA828 was heading northwest to GT at FL 350 and merged with AAL720 heading north to GT at FL 350.	F-5
23	4E Radar	R62/63	4	Error	AAL658 & CMM314 - When radar was lost both aircraft were at FL 350. There was no longitudinal separation.	I-10
23	4E Radar	R62/63	4	Error	AAL401 & AAL679 - Both aircraft were at FL 370 when radar was lost. There was no longitudinal separation	I-10
23	4E Radar	R62/63	4	Error	ARU758 & VIA822 - ARU758 was at FL 280 on A315 estimating ZIN at 22:30. VIA822 was at FL 280 estimating ZIN at 22:22. (Need 10 minutes)	I-10
23	4E Radar	R62/63	4	Error	CWC173 & VAL176 - CWC173 was at FL 350 on A315 estimating ZIN at 22:30. VAL176 was at FL 350 estimating ZIN at 22:22. (Need 10 minutes)	I-10
23	4E Radar	R62/63	4	Deviation	LHN892 wrong altitude for direction of flight not coordinated with New York.	I-10
24	4E Weather	R62/63	3	Error	Controller had incorrect coordination strip. Needed SLAPP but had BOTES. Controller estimated the correct time at SLAPP to be 0109Z put that time on the BOTES strip, changed the name BOTES to SLAPP and coordinated that time. When he got the correct SLAPP strip the correct estimated time was 0058Z. The revised, correct time was not re-coordinated.	J-8
24	4E Weather	R62/63	3	Error	DOA472 & SPP896 - DOA472 descended to FL 270 to land at MDPP. SPP896 climbed to FL 280 from a non-radar departure at MDPP. SPP896 should have been stopped at a lower altitude.	J-8

Day	Scenario	Sector	Interval	Situation Type	Explanation	Team-#Errors
24	4E Weather	R62/63	4	Error	AAL141 & CTC410 - Radar was lost with CTC410 descending to FL 370 and AAL141 at FL 390. (non-radar error).	J-8
19	4R	R62/63		RVSM	RVSM // Use of RVSM in non-WATRS area.	F-5
19	4R	R62/63	2	Error	USA167 & M3390 - USA167 was climbing out of FL 350 to FL 370 over SLAPP at 20:43. M3390 was at FL 370 over SLAPP at 20:51. (Less than 10 minutes separation)	F-5
23	4R	R62/63	2	Deviation	ROY173 was northbound at FL 310 and not coordinated as wrong altitude for direction of flight with New York.	I-10
24	4R	R62/63	2	Deviation	AAL719 was in the wrong bay and was not coordinated with Santo Domingo. Error was corrected at 22:18	J-8
18	4R	R62/63	3	Error	APA283 & AAL657 - APA283 was over SLAPP at 19:27 and AAL657 was over GEJAY at 19:32. Both were at the same altitude without non-radar separation.	D-6
18	4R	R62/63	3	RVSM	RVSM // AAL728 cleared to FL 360 40 miles south of GTK. Not in RVSM Area. ACA reached FL 360 at 19:45 15 miles north of GTK. Later descended to FL 340 30 miles north of GTK.	D-6
18	4R	R62/63	3	Deviation	AAL216 entered with no handoff.	D-6
24	4R	R62/63	3	Error	ROY173 & APA283 - New York requested FL 310 for ROY173. D-side showed FL 320 at 22:25. CFG158 was over SEKAR at 22:29 descending to FL 110. APA283 over SEKAR at 22:40 descending to 11,000 ft. Need 15 minutes.	J-8
18	4R	R62/63	4	RVSM	RVSM // DOA241 entered non-RVSM area at FL 380.	D-6
23	4R	R62/63	4	Error	DOA474 & N404PA - DOA474 and N404PA were both at FL 330 very close to WATRS intersection. Non radar separation was not ensured.	I-10